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INFANT MORTALITY
AND ITS CAUSES



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INFANT MORTALITY AND ITS CAUSES

*With an Appendix on the Trend
of Maternal Mortality Rates in
the United States*

BY

ROBERT MORSE WOODBURY, Ph.D.

*Formerly Director of Statistical Research,
United States Children's Bureau*



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To

Julia C. Lathrop

First Chief of the United States Children's Bureau

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PREFATORY NOTE

With the exception of two chapters the material which is presented in this volume has appeared in scattered papers in technical journals. These papers are here reproduced with such minor changes as seemed necessary to weave them together into a fairly connected exposition of the subject. In them are summarized the principal conclusions which flow from the detailed investigations into infant mortality made by the United States Children's Bureau. Although the materials gathered by the Bureau have been freely utilized in these studies, the responsibility for the conclusions stated here is assumed by the author.

Those who are interested in studying the conclusions in the light of the numbers of cases involved or in following in further detail the points presented in these chapters, as well as those who are interested in other points than the ones which are discussed here, are referred to the Children's Bureau bulletins on Infant Mortality, and in particular to Causal Factors in Infant Mortality, publication No. 142, which summarizes and combines the results of the separate city studies.

Acknowledgments are due to the United States Children's Bureau and to the Bureau of the Census for materials used in these studies. Special mention should be made of the generous assistance given by Sir Truby King, whose work in saving babies in New Zealand has won world-wide attention, by many New Zealand government officials, and by officers of the

Royal New Zealand Society for the Health of Women and Children in connection with a study of conditions affecting infant mortality in that country undertaken during a visit to New Zealand early in 1920.

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ROBERT M. WOODBURY.

Washington, D. C.

CHAPTER I

INFANT MORTALITY IN THE UNITED STATES, 1915 TO 1921¹

In the study of any social problem such as that of infant mortality, knowledge of the facts relating to it is the first essential. What proportion of the children born die during the first year of life? What are the causes of these deaths? How can they be prevented? Are preventive measures which have been adopted effective? In what directions should further efforts be made? These questions and others closely related to them must be answered if we are to win control over our problem of infant mortality.

In the United States knowledge of infant mortality, its extent and causes, has been and still is limited. The calculation of infant mortality rates in the customary manner, by finding the number of deaths under one year of age per 1,000 live births, is dependent upon good registration of births and deaths. But as com-

¹ The material in this chapter is taken by permission from *Decline in Infant Mortality in the United States Birth-Registration Area, 1915 to 1921*, published in the May, 1923, issue of the *American Journal of Public Health*, Vol. XIII, pp. 377-383. Since comparatively little change has taken place in the infant mortality rate in this area since 1921, when the rate was 75.6, the discussion of changes has not been altered but includes data only up to 1921, as originally written. In 1922 the rate was 76.2, and in 1923, 77.1; the rate for 1924, 70.8, and a provisional figure for 1925, 71.5, for the entire birth registration area, exclusive of Massachusetts, Utah, and Wyoming, indicated a further decline in infant mortality, but at the time of going to press the detailed rates by causes even for 1924 were not available.

pared with other countries the United States has been singularly backward in such registration. Statistics of births and deaths are available for England, for example, since 1837 and for Sweden since 1749, but in this country, except in a few states such as Massachusetts, Connecticut and Rhode Island for which figures run back to the middle of the past century, such statistics are of very recent origin. Not until 1915 did the Federal Bureau of the Census commence the annual publication of birth statistics for the "Birth registration area," an area which included states in which, in the judgment of the bureau, birth registration was at least 90 per cent complete. In 1915 this area was composed of only 10 states and the District of Columbia, and included within its limits only 31 per cent of the population of the country. A number of other states were added as their birth registration was tested and accepted, until in 1921 the area included 29 states and the District of Columbia and comprised 60 per cent of the population. For this area, then, fairly satisfactory statistics are available for a study of infant mortality rates and their trend, and for an analysis of the principal causes of death.

In the expanding birth registration area the infant mortality rate fell from 99.9 in 1915 to 75.6 in 1921, if the statistics can be accepted at their face value.² This represents a decrease of 24 per cent in the six-year period, a truly remarkable record.

In this decrease, however, is reflected not only an actual decrease in mortality due to improvement in

² Figures compiled from Birth Statistics, 1915, p. 10 and 1921, p. 29.

conditions affecting infant health, but also changes due to the addition of new territory. Whenever a state was added in which the mortality was markedly below that in the rest of the area, the rate for the entire area was lowered even though no real improvement in conditions had taken place. Conversely, whenever a state was added in which the mortality was markedly above that in the rest of the area, the rate for the entire area was raised even though no change in conditions had occurred.

An examination of the rates in table 1 shows clearly the influence of such additions of new territory. In 1916 the only State added to the area, Maryland, had an infant mortality rate, 121, considerably above that of the original area for the same year, 100. But in each of the other years the territory added had a rate lower than that of the area previously included.

Part of the apparent decrease in the infant mortality rate in the expanding birth-registration area must, therefore, be ascribed to the addition of states in which these rates were low.

A simple method of measuring the true fall in the infant mortality rate, as distinguished from the apparent decrease due to low rates in new territory added to the area, is to study the decrease in the original area (exclusive of Rhode Island).³ In this area the rate fell from 99.6 to 78.7, a decrease of 20.9 per cent as compared with the decrease of 24.3 per cent, from 99.9

³ Rhode Island, though included in the original birth-registration area in 1915, is treated as separate from it in this discussion, since for the two years 1919 and 1920 the state was dropped from the birth-registration area altogether.

to 75.6, in the rate for the expanding area. Thus only about one-seventh of the decrease in the rate can be accounted for by the inclusion of new territory.

TABLE 1

*Infant mortality rates in expanding birth-registration area, 1915 to 1921**

AREA	1915	1916	1917	1918	1919	1920	1921
Expanding birth-registration area.....	99.9	101.0	93.8	100.8	86.6	85.8	75.6
Original area† (excluding Rhode Island).....	99.6	100.0	96.1	105.8	88.7	89.9	78.7
Rhode Island.....	120.3	111.2	107.5	125.6	†	†	92.7
State added in 1916§.....		121.0	119.9	140.4	105.4	104.1	93.6
States added in 1917**.....			88.1	90.4	82.4	79.4	71.3
States added in 1919††.....					86.2	88.2	75.5
State added in 1920‡‡.....						64.2	58.6
States added in 1921§§.....							73.0

* Compiled from Birth Statistics, 1915-1920, and Infant Mortality in the Birth-Registration Area of the United States: 1921. U. S. Bureau of the Census.

† Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, Michigan, Minnesota, District of Columbia.

‡ Dropped from birth-registration area.

§ Maryland.

** Virginia, North Carolina, Ohio, Indiana, Kentucky, Wisconsin, Kansas, Utah, Washington.

†† South Carolina, Oregon, California.

‡‡ Nebraska.

§§ New Jersey, Delaware, Mississippi.

This method, however, does not take into account the decrease in rates in territories added to the original registration area.

The tendency toward a fall in infant mortality rates appears, as shown in table 1, not only in the original birth-registration area but also in each addition to

that area. While in the original birth-registration area (exclusive of Rhode Island), as already stated, the rate fell 20.9 per cent during the period 1915 to 1921, in Rhode Island the percentage of decrease was slightly larger, 22.9. During the period from 1916 to 1921 the rate in Maryland, which was added in 1916, fell 22.6 per cent; during the period from 1917 to 1921 in the nine states added in 1917 the rate fell 19.1 per cent. Decreases of 12.4 per cent and 8.7 per cent appeared in the rates for the areas added in 1919 and 1920 during the periods from the time of their admission to 1921.⁴

A method of taking into account the decrease in mortality rates within the added territory as well as within the original territory—giving to each fall in rate its due weight in the calculation—is as follows. The percentage of decrease from each year to the next in the territory common to both years is first ascertained. The initial rate in 1915 is then multiplied by the percentage of decrease from 1915 to 1916 in the territory common to both years; the result is multiplied by the percentage of decrease from 1916 to 1917 in the territory common to these years; and the successive results are multiplied by the corresponding percentages of decrease to form a series of adjusted figures which measure the true fall in the infant mortality rates of the birth-registration area. The series so constructed is as follows, starting with the initial rate of 99.9 (for the original birth-registration area, including Rhode Island): 99.9, 100.2, 96.4, 103.8, 89.4,

⁴ It should be noted that with a given rate of decrease the percentage decrease over a period of time varies with the length of the period.

89.0, and 78.5. It will be seen by comparing this series with the series of rates in the original birth-registration area that the tendency to decrease is substantially the same in the original area and in the added territory.

A second factor that must be taken into account before a definite conclusion can be formed as to the true amount of decrease is the improvement in birth registration. Since the number of registered births is used as the denominator of the rate fraction, it follows that an improvement of one per cent in the proportion of registered births would result in an apparent decrease of one per cent in the infant mortality rate. Hence, in order to be sure that the figure, 20.9 per cent, for the original birth-registration area (exclusive of Rhode Island) represents a true decrease the questions must be considered: Has birth registration improved? And if so, how much?

Since birth rates are calculated by comparing registered births with population, an improvement in registration is likely to lead to an apparent increase in the birth rate. Hence, such an apparent increase, especially in view of the fact that birth rates have been falling in recent years, creates a suspicion, and a continued increase creates a presumption, that registration has improved. Evidence of such improvement in certain states may be found, for example, in the increase in the colored birth rate of Pennsylvania from 17.5 in 1916 to 23.8 in 1921, and in the increase in the white birth rate in the District of Columbia from 16.9 in 1916 to 19.5 in 1921.

A rough measure of the fall in birth rate in the several

states of the birth-registration area would be found in the ratio of the 1915 to the 1921 rate, provided no change in the completeness of registration had occurred. The ratios for the different states are found on examination, however, to vary markedly. For example, the 1915 rate in Connecticut was 11.3 per cent, in Massachusetts 8.1 per cent, and in New York 5.7 per cent above the rates for those states in 1921, while in three states, Maine, New Hampshire, and Vermont, and in the District of Columbia the 1915 rates were lower than those in 1921. The explanation of these marked variations is doubtless to be sought in improvements of birth registration in the latter group of states.

If the average amount of the fall in the birth rate throughout the area could be determined, it would be possible to make an estimate of the improvement in birth registration. A comparison of the registered births during the year preceding the censuses of 1910 and 1920 with the enumerated population under one year of age indicates that registration was most nearly complete in Massachusetts and New York. In these states, then, the decrease in birth rate from 1915 to 1921 probably represented the true fall. Assuming that the average, 6.9 per cent, of the percentages of decrease in these two states represented approximately the decrease for the entire area it may be estimated that 2.9 per cent more births would have been registered in 1915 if birth registration had been as good in that year as in 1921. If this figure be accepted as representing roughly the improvement in birth registration during this period, then the infant mortality rate of 78.7 in 1921 should have been compared with a rate of

96.7 in 1915 (instead of 99.6), and the corrected decrease in infant mortality would be 18.4, instead of 20.9, per cent.

This result indicates that only a small part of the fall in the infant mortality rate can be attributed to improvements in birth registration and that most of it must have been due to changes in conditions affecting the infants' health. The conclusion is therefore correct that from 1915 to 1921 a marked decrease took place in the infant mortality rate in the United States birth registration area.

What are the causes of infant mortality and in which of these causes has the decrease been greatest? Has the decrease taken place in cities, or in rural districts or in both? How do cities and rural districts compare as regards the reduction of infant deaths from specific causes? For simplicity of statement in the following discussion of these questions the figures for the original birth registration States of 1915, exclusive of Rhode Island, are taken as substantially accurate and the conclusions are stated without the qualifications necessary to make allowance for the improvement in birth registration. Since such an improvement affects the rates from all causes equally, it should be borne in mind that in order to arrive at a correct idea of the true change in the rates, all the decreases should be diminished by 2.9 per cent—the estimated improvement in birth registration—and all the increases should be increased by the same amount.

The changes in the mortality rates for the important causes of death under one year of age are given in detail in table 2, which shows the rates in each of the years

from 1915 to 1921 and the percentage changes in rates during that period. In 1921 a revised list of causes of death was used, but the changes made in the revision do not affect the comparability of the broad groups of causes nor, with one or two exceptions, do they affect the individual causes.⁵

The mortality rate from gastric and intestinal diseases fell from 24.58 in 1915 to 16.08 in 1921, a decrease of over one-third, or 34.6 per cent. This decrease, it may be noted, was continuous throughout the period, except for a slight increase from 1915 to 1916. The tendency toward a progressive decline suggests that the decrease is due largely to a permanent improvement in health conditions rather than to unusually favorable summer temperatures and weather of a single year.

The rate from respiratory diseases fell from 16.57

⁵ The changes in 1921 affecting the causes listed in table 2 were as follows: Deaths from duodenal ulcer, formerly classified with diarrhea and enteritis, were included with diseases of the stomach (this change affects very few deaths under one year); deaths from capillary bronchitis, formerly included with acute bronchitis, were classified with broncho-pneumonia; deaths from the joint causes, influenza and lobar pneumonia, formerly classed with pneumonia, were included with influenza; deaths from acute miliary tuberculosis, formerly included under tuberculosis of the lungs (title 13 of the abridged list), were divided, deaths from acute miliary tuberculosis of lungs were included with the new title "tuberculosis of the respiratory system" and deaths from all other types of miliary tuberculosis were included with other forms of tuberculosis. Other changes were made, chiefly in nomenclature, such as tuberculosis of the meninges and central nervous system for tuberculous meningitis; meningococcus meningitis for cerebro-spinal fever, formerly subdivision 3 under meningitis, diphtheria for diphtheria and croup. With these exceptions the rates shown in the tables are comparable.

TABLE 2
*Decline in infant mortality rates, by cause of death, 1915 to 1921: United States birth-registration area as of 1915 (exclusive of Rhode Island)**

CAUSE OF DEATH†	INFANT MORTALITY RATE						PER CENT DECREASE, 1915-1921‡
	1915	1916	1917	1918	1919	1920	
All causes.....	99.55	99.95	96.08	105.83	88.74	89.92	21.0
Gastric and intestinal diseases.....	24.58	25.05	23.38	23.18	18.97	18.69	34.6
Diseases of the stomach.....	1.45	1.40	1.07	1.33	1.21	1.05	41.8
Diarrhea and enteritis.....	23.13	23.66	22.31	21.85	17.76	17.64	34.1
Respiratory diseases.....	16.57	15.82	16.44	18.41	14.49	14.95	32.2
Acute bronchitis.....	2.58	2.52	2.66	2.58	2.29	2.31	46.9
Bronchopneumonia.....	9.86	9.40	9.38	10.67	9.08	9.48	24.3
Pneumonia.....	4.13	3.90	4.40	5.16	3.13	3.16	41.9
Malformations.....	6.44	6.85	6.68	6.95	6.94	7.05	7.08
Early infancy.....	34.35	33.29	32.40	34.13	31.60	31.54	10.0§
Premature birth.....	18.53	19.23	19.18	20.65	18.95	19.03	10.8
Congenital debility.....	11.69	9.92	8.83	9.64	8.52	7.96	1.7
Injuries at birth.....	4.13	4.14	4.39	3.84	4.13	4.55	37.1
Other communicable diseases.....	7.62	8.92	7.95	14.66	8.55	9.48	22.7§
Measles.....	0.72	1.44	0.93	1.09	0.58	1.23	21.7
Scarlet fever.....	0.10	0.05	0.07	0.04	0.05	0.11	24.7
Whooping cough.....	1.93	2.21	1.99	2.95	1.31	2.77	40.6§
Diphtheria.....	0.58	0.52	0.52	0.45	0.49	0.49	1.83
Influenza.....	0.62	0.86	0.74	6.76	3.07	2.13	5.2
Dysentery.....	0.22	0.19	0.16	0.21	0.15	0.15	22.5
Erysipelas.....	0.55	0.58	0.57	0.49	0.47	0.49	9.2
Tetanus.....	0.08	0.09	0.07	0.06	0.06	0.04	40.6
							21.4
							36.8

Tuberculosis of the respiratory system.....	0.49	0.54	0.56	0.49	0.46	0.39	0.27	44.9
Tuberculosis of the meninges, etc..	0.81	0.83	0.83	0.78	0.65	0.57	0.53	35.6
Other forms of tuberculosis.....	0.26	0.25	0.23	0.24	0.19	0.17	0.19	26.9
Syphilis.....	1.26	1.34	1.28	1.10	1.06	0.93	0.84	32.9
External causes.....	1.01	1.06	1.27	0.99	0.88	0.86	0.80	20.2
Diseases ill-defined and unknown....	0.69	0.81	0.78	0.85	0.80	0.69	—**	—**
All other causes.....	8.30	8.15	7.18	6.67	6.51	6.65	6.87	23.5
Meningitis.....	0.87	0.76	0.83	0.76	0.65	0.59	0.62	28.9
Convulsions.....	1.57	1.24	1.03	1.16	1.06	0.97	0.80	48.6
Diseases of the heart.....	0.40	0.34	0.36	0.36	0.37	0.35	0.25	36.5
Other.....	5.46	5.81	4.96	4.40	4.43	4.73	5.20††	15.5††

* Compiled from Birth Statistics, 1915 to 1921; Mortality Statistics, 1915 to 1921.

† In this table only those diseases most important during infancy are shown separately. Except for the group of all other causes, each group included in the specific diseases which are shown separately. The numbers of the International List included in the various groups are (the numbers of the old list in parentheses): Gastric and intestinal diseases, 111-113 (102-104); respiratory diseases, 99-101 (89, 91, 92); malformations 159 (150); early infancy 160-163 (151-153); other communicable diseases, 7-11, 16, 21, 29, 31-38 (6-10, 14, 18, 24-35, 37); external causes, 175-203 (155-186); diseases ill-defined and unknown, 204-205 (187-189); the remaining numbers are included with all other (—).

See note 5, p. 9, for effect of changes in classification upon the comparability of the rates in 1921 with the rates for the preceding years, 1915-1920.

‡ The percentages were calculated from rates carried to three places.

§ Per cent of increase.

** Figures not available.

†† Includes ill-defined and unknown.

in 1915 to 11.23 in 1921, a decrease of nearly one-third, or 32.2 per cent. The rise of the rate in 1918 probably shows the effect of the influenza epidemic; since, as already noted, deaths ascribed jointly to lobar pneumonia and influenza were at that time classified as pneumonia, the deaths due to these joint causes would be likely to increase during the influenza epidemic. Bronchopneumonia also showed an increase in 1918, probably due to the same cause. Although the general tendency of the rates from respiratory diseases is downward, it may be pointed out that, leaving the year 1918 out of consideration, the percentage decrease from 1920 to 1921 was greater than that from any other year of the period to the next.

The death rate from malformations shows a slight increase from 6.44 in 1915 to 7.08 in 1921.

The mortality rate from causes peculiar to early infancy decreased from 34.35 in 1915 to 30.63 in 1921, a decrease of one-tenth, or 10.8 per cent. In this case the fall in the rate was a regular decrease from year to year, with the exception of 1918 when influenza may have increased the mortality from these causes in the same way that it increased the mortality of pregnant women. Of the three causes which are included in this group, premature birth showed comparatively little change, though the rate of 18.21 in 1921 was lower than any other in the seven-year period, and deaths from injuries at birth showed a tendency, especially in 1920 and in 1921, to increase. Practically all the decrease in the group was in deaths from congenital debility. The death rate from this latter cause fell from 11.69 in 1915 to only 7.35 in 1921, a decrease of

37.1 per cent.⁶ The decrease in deaths from congenital debility may perhaps reflect an increased accuracy in the certification of cause of death, or may be attributable to a decrease in the death rate from such causes as malnutrition, marasmus, wasting, weakness, and emaciation, which are ascribed to this rubric if they are given as causes of death for infants under one year of age.

The mortality rate from "other communicable diseases," a group which includes the epidemic diseases and tetanus, tuberculosis and syphilis, fell from 7.62 in 1915 to 5.97 in 1921, a decrease of one-fifth, or 21.7 per cent. As would be expected, the rates from this group of causes exhibit marked fluctuations from year to year. The high figure of 14.66 for 1918 shows the effect of the influenza epidemic. The rates from some of the individual causes show characteristic trends or fluctuations. Measles appears to have a two-year cycle of fluctuation, the rate being high and low in alternate years; but the rate for 1921 was lower than that for any other year of the seven-year period. Scarlet fever, on the other hand, had in 1921 a rate higher than that for any other year of the period. Whooping cough, like measles, seems to show high and low mortality in alternate years, and in 1921 was responsible for a smaller death rate than in any year except 1919. The

⁶ Further analysis of the deaths from "congenital debility" of the abridged list into the two groups of which it is composed, "congenital debility proper" (151 (2) of the old list) and "other causes peculiar to early infancy" (152 (2) and 153 of the old list) shows that the reductions occurred mainly in the death rate from congenital debility proper. The rate from this cause fell from 8.53 in 1915 to 4.3 in 1921, while the rate from "other causes peculiar to early infancy" fell only from 3.16 in 1915 to 3.06 in 1921.

1921 rate from diphtheria was equal to that of 1918; these were the lowest of the period and were one-fifth lower than the rate for 1915. The mortality rate from influenza increased from 0.62 in 1915 to 6.76 in 1918, and fell off slowly to 3.07 in 1919 and to 2.13 in 1920; in 1921 it fell to 0.56, a figure lower even than that for 1915. The rates from dysentery, erysipelas and tetanus all showed a tendency to fall. The mortality from tuberculosis (all forms) fell from 1.56 in 1915 to 0.99 in 1921, a decrease of over one-third. Syphilis showed a decrease of nearly one-third in the period under review. Though not shown separately in the table, it may be noted that the death rate from cerebrospinal fever increased from 0.13 in 1915 to 0.32 in 1917, from which it fell in 1921 to 0.16. With one or two exceptions, then, the mortality rates from these epidemic and communicable diseases decreased markedly during the period from 1915 to 1921.

The death rate from external causes fell from 1.01 in 1915 to 0.80 in 1921, a decrease of one-fifth. The death rate from all other causes, including the ill-defined and unknown, fell from 8.99 in 1915 to 6.87 in 1921, or 23.5 per cent. Among the causes included in this group convulsions showed a decrease of nearly one-half, 48.6 per cent, and diseases of the heart a decrease of over one-third, 36.5 per cent.

A comparison of the infant mortality rates in urban and rural areas is of special interest. The decrease from 1915 to 1921 in urban areas, that is, in cities of 10,000 population and over,⁷ was both actually and

⁷ In the urban area were included cities which at the last preceding census had at least 10,000 population. Three cities which

relatively greater than in rural districts—24.0 per cent as compared with only 15.6 per cent (table 3). Although the rate for cities was in 1915 nearly 9 points higher than that for rural areas, by 1921 it was 1 point below the rural rate.

The comparison by cause of death shows a similarly greater decrease in urban than in rural areas in the rates from gastric and intestinal diseases. In 1915 the rate for the cities was slightly over 5 points, or nearly 24.3 per cent, higher than the rate for the rural areas, but in 1921 the urban rate was nearly 1 point, or 5.8 per cent, lower than the rural rate.

Progress of infant-welfare work in the cities and continued progress in the efficient regulation and supervision of the production, transportation, and distribution of milk are doubtless responsible for this shift in the relative position of urban and rural mortality from gastric and intestinal diseases. This change is all the more noteworthy because of the handicaps which the cities have had to overcome in order to insure a pure milk supply, and also because a larger proportion

were included in the urban area in 1915 were transferred to the rural in 1921 because their populations had fallen to less than 10,000 each; their infant mortality rates in 1915 averaged 86.2, or somewhat less than the average for urban districts. On the other hand, 54 cities which were not included in the urban area in 1915 were added in 1921, on account of an increase of their populations past the 10,000 mark. The infant mortality rate in these cities in 1921 was 77.43, or slightly less than the rate for the urban areas (table 3). For the areas classified as urban both in 1915 and in 1921 the percentage of decrease was 24.1, and for the areas classified as rural in both years it was 15.5. The percentage decrease for the urban areas was, therefore, actually somewhat greater, as compared with the rural, than the table indicates.

TABLE 3

*Decline in infant mortality rates, for urban and rural districts, by cause of death, 1915 to 1921; United States birth-registration area as of 1915 (exclusive of Rhode Island)**

CAUSE OF DEATH†	URBAN			RURAL		
	Infant mortality rate		Per cent decrease, 1915 to 1921‡	Infant mortality rate		Per cent decrease, 1915 to 1921‡
	1915	1921		1915	1921	
All causes.....	102.94	78.24	24.0	94.11	79.43	15.6
Gastric and intestinal diseases..	26.57	15.73	40.8	21.37	16.69	21.9
Diseases of the stomach.....	1.03	0.60	42.1	2.12	1.28	39.4
Diarrhea and enteritis.....	25.54	15.13	40.7	19.25	15.41	20.0
Respiratory diseases.....	17.70	11.50	35.1	14.75	10.77	27.0
Acute bronchitis.....	2.71	1.39	48.6	2.38	1.34	43.8
Bronchopneumonia.....	11.08	7.83	29.4	7.88	6.81	13.6
Pneumonia.....	3.91	2.28	41.8	4.48	2.62	41.7
Malformations.....	6.17	6.77	9.8§	6.87	7.63	11.2§
Early infancy.....	34.81	31.08	10.7	33.63	29.83	11.3
Premature birth.....	18.63	18.32	1.7	18.36	18.01	1.9
Congenital debility.....	11.75	7.15	39.1	11.59	7.71	33.5
Injuries at birth.....	4.42	5.61	26.8§	3.67	4.12	12.3§
Other communicable diseases....	8.38	5.98	28.6	6.39	5.94	7.2
Measles.....	0.90	0.48	47.1	0.42	0.65	55.1§
Scarlet fever.....	0.10	0.15	47.0§	0.10	0.13	29.1§
Whooping cough.....	1.83	1.65	10.1	2.10	2.17	3.3§
Diphtheria.....	0.70	0.53	25.0	0.38	0.31	18.9
Influenza.....	0.40	0.42	4.0§	0.97	0.82	15.5

* Source: Manuscript figures furnished by courtesy of the United States Bureau of the Census.

† See note 5, page 9, for effect of changes in classification upon the comparability of the rates from the several causes in the two years. See also second note, table 2.

‡ The percentages were calculated from rates carried to three places.

§ Per cent increase.

TABLE 3—*Concluded*

CAUSE OF DEATH†	URBAN			RURAL		
	Infant mortality rate		Per cent decrease, 1915 to 1921‡	Infant mortality rate		Per cent decrease, 1915 to 1921‡
	1915	1921		1915	1921	
Other communicable diseases —continued						
Dysentery.....	0.22	0.09	57.6	0.22	0.20	11.3
Erysipelas.....	0.67	0.49	26.6	0.36	0.33	9.2
Tetanus.....	0.07	0.04	44.6	0.08	0.06	24.1
Tuberculosis of the respiratory system.....	0.55	0.29	46.4	0.40	0.23	43.0
Tuberculosis of the meninges, etc.....	1.03	0.61	40.4	0.48	0.37	21.8
Other forms of tuberculosis...	0.26	0.21	20.5	0.26	0.16	38.8
Syphilis.....	1.65	1.03	37.6	0.63	0.51	18.2
External causes.....	0.98	0.74	25.1	1.04	0.92	11.5
All other causes.....	9.52	6.44	32.4	10.63	7.65	28.1
Convulsions.....	1.25	0.58	53.9	2.08	1.21	41.7
Diseases of the heart.....	0.34	0.17	48.5	0.50	0.40	20.5
Other**.....	7.72	5.69	26.3	8.64	6.03	30.2

** Includes diseases ill-defined and unknown and meningitis.

of infants probably are artificially fed in the urban than in the rural areas.⁸

⁸ Studies made by the Children's Bureau in selected rural areas and cities indicate a larger proportion of infants artificially fed in the cities. Thus, of infants surviving at the end of the third month the proportion artificially fed was 6.1 per cent in a rural county in Kansas and 9.4 per cent and 11.3 per cent in rural districts in two counties in Wisconsin, as compared with percentages of 15.5, 16.1, 19.2, 24.7, 28.8, and 30.6 in Akron, Ohio; Saginaw, Mich.; Waterbury, Conn.; New Bedford, Mass.; Manchester, N.H.; and Brockton, Mass., respectively. See *Maternity and Infant Care in Two Rural Counties in Wisconsin*, by Dr. Florence Brown

The mortality from respiratory diseases was higher in the cities than in the rural areas both in 1915 and in 1921, although the percentage of decrease was greater for the cities.

In both urban and rural areas, the mortality from malformations increased. The rates in the cities were less than those in the rural districts in both years and showed a somewhat smaller increase during the seven-year period. The death rate from injuries at birth likewise showed an increase in both urban and rural districts; in this case the increase was greater for the urban than for the rural areas. The mortality from premature birth showed little change, while that from congenital debility showed marked decreases in the areas of both types, the percentage of decrease being greater for the cities.

It is interesting to note that for most of the epidemic and other communicable diseases, notably diphtheria, erysipelas, tuberculosis, and syphilis, the rates were higher in cities than in rural districts. On the other hand, whooping cough appeared to be more prevalent in the rural areas.

The decreases in the infant mortality rates from the

Sherbon and Elizabeth Moore, p. 92, U. S. Children's Bureau Publication No. 46; Maternity and Infant Care in a Rural County in Kansas, by Elizabeth Moore, p. 42, U. S. Children's Bureau Publication No. 26; Infant Mortality: Results of a Field Study in Saginaw, Mich., Based on Births in One Year, by Nila F. Allen, p. 21, U. S. Children's Bureau Publication No. 52; Infant Mortality: Results of a Field Study in Waterbury, Conn., Based on Births in One Year, by Estelle B. Hunter, p. 132, U. S. Children's Bureau Publication No. 29; and Infant Mortality: Results of a Field Study in Brockton, Mass., Based on Births in One Year, by Mary V. Dempsey, p. 22, U. S. Children's Bureau Publication No. 37.

several causes are reflected in decreases in the death rates at each of several different ages under one year, as shown in table 4. Of especial interest are the marked decrease, from 44.33 in 1915 to 40.80 in 1921, in the mortality rate for the first month of life and the

TABLE 4

*Decline in infant mortality rates at different ages under 1 year, in urban and rural areas, 1915 to 1921; United States birth-registration area (exclusive of Rhode Island) as of 1915**

AGE AT DEATH	DEATHS PER 1,000 LIVE BIRTHS					
	Area		Urban		Rural	
	1915	1921	1915	1921	1915	1921
Total.....	99.55	78.67	102.94	78.24	94.11	79.43
Under 1 month.....	44.33	40.80	43.30	40.15	45.99	41.96
Under 1 week.....	30.11	29.32	29.55	29.28	31.03	29.39
Under 1 day.....	15.03	14.64	14.63	14.58	15.60	14.74
1 day, under 2.....	4.84	4.61	4.76	4.57	4.96	4.67
2 days, under 3.....	3.49	3.59	3.50	3.73	3.49	3.35
3 days, under 1 week.....	6.75	6.48	6.61	6.40	6.97	6.63
1 week, under 2.....	5.99	5.03	5.77	4.78	6.34	5.47
2 weeks, under 3.....	4.56	3.65	4.41	3.45	4.80	4.00
3 weeks, under 1 month.....	3.67	2.80	3.57	2.63	3.83	3.11
1 month, under 2.....	9.01	6.53	9.14	6.32	8.80	6.90
2 months, under 3.....	7.55	5.17	7.72	4.89	7.27	5.69
3 months, under 6.....	16.80	11.59	17.99	11.50	14.87	11.76
6 months, under 9.....	12.46	8.30	13.90	8.62	10.13	7.73
9 months, under 12.....	9.41	6.28	10.89	6.76	7.04	5.42

* Source: Manuscript figures furnished by courtesy of the Bureau of the Census.

fact that the decrease was greater in the rural than in the urban areas. The urban rate of neonatal mortality was lower than the rural in both years. Comparing the urban and rural rates in 1915, it appears that the urban rates exceeded the rural for each age except the first

month of life; in 1921, however, the urban rates exceeded the rural only for the last six months of the first year of life.⁹

Causes of the decrease in infant mortality in the United States birth-registration area during the period from 1915 to 1921 are to be found in the movement for the protection of the health of infants and, doubtless, in the movement for general public-health protection and sanitation. The growth within the past few years of public interest in infant-welfare work, in child-health work, and (recently) in prenatal work for expectant mothers has been noteworthy. The distribution of health-instruction pamphlets to mothers by city, state, and federal agencies has assumed more and more comprehensive proportions. The establishment of child-hygiene divisions in 36 states during the period under review (and of 8 more in 1922) is an indication of the awakened interest in the problems of infant and child health. Other factors in this decrease, the importance of which should not be slighted, are the progress of medical science, the improvement of the technical training of physicians, and the increased number of pediatricists. The steady extension of sanitation to benefit larger numbers of the population and the improvement of standards for milk distribution likewise should not be overlooked. All these factors doubtless played their parts in the decrease of the infant mortality rate by one-fifth in the short space of six years.

⁹ These conclusions depend in part upon assumptions relative to the completeness of birth registration. But it is probable that birth registration improved more in rural than in urban areas, and consequently that the decrease in mortality rates for urban areas is understated as compared with that in rates for rural areas.

Much, however, remains to be accomplished. Even the low rate of 1921 is by no means to be accepted as a final and satisfactory minimum. Some idea of the possibility of further reductions in infant mortality can be formed by comparing the rates in the birth-registra-

TABLE 5
*Comparative infant mortality rates, by cause of death, United States birth-registration area as of 1915, exclusive of Rhode Island, and New Zealand: 1921**

CAUSE OF DEATH	INFANT MORTALITY RATES, 1921	
	U. S. birth-registration area†	New Zealand
All causes.....	78.67	47.82
Gastric and intestinal diseases.....	16.08	4.13
Respiratory diseases.....	11.23	4.80
Malformations.....	7.08	5.01
Early infancy.....	30.63	26.22
Other communicable diseases.....	5.97	2.21
External causes.....	0.80	0.39
All other causes.....	6.87	5.08

* Compiled from Birth Statistics, 1921, and Report on the Vital Statistics of the Dominion of New Zealand for the year 1921, pp. 1, 24-33. The deaths in New Zealand are classified according to the International List of Causes of Death in use during the period 1911-1920. For the specific causes included in each group see second note, table 2.

† As of 1915, exclusive of Rhode Island.

tion area as established in 1915, exclusive of Rhode Island, with those in New Zealand, as in table 5. In that year the New Zealand rate from gastric and intestinal diseases was about one-fourth, from respiratory diseases less than half, from causes peculiar to early

infancy six-sevenths, and from "other communicable diseases" three-eighths of the corresponding rates in the United States birth-registration area.

A further reduction in the infant mortality rate of the United States may be expected especially as a result of the work of state divisions of child hygiene and of the establishment of facilities providing prenatal care for mothers. The value of such work has been proved but in many cases it is still in its initial stages. The growth of prenatal work during the next decade and the steady extension of infant-welfare activities to reach larger and larger numbers of the babies born should be accompanied by a decreasing infant mortality rate.

CHAPTER II

PROBLEMS IN THE STUDY OF INFANT MORTALITY¹

The preceding chapter has discussed the growth of the registration area and the gradual accumulation of data for the determination of the infant mortality rate and for the study of its causes. But even if full data from birth and death records were available for the entire country, many questions of great importance would remain unanswered unless supplementary information could be obtained. The official statistics of births and deaths throw no light, for example, upon the influence of type of feeding upon infant mortality. Economic factors are entirely ignored in such statistics, except in so far as the father's occupation may perhaps indirectly indicate economic position. Even with regard to certain factors, such as race and nationality, for which information is available from birth and death records, the data do not permit the type of analysis necessary to show the true influence of the particular factor independent of and distinguished from the influences of others with which it is usually associated or correlated. For such analysis additional data are needed in such form as will permit disentangling the complex causes which are at work.

The studies of infant mortality made by the Federal Children's Bureau, created by Act of Congress in 1912,

¹ Adapted by permission from *Infant Mortality Studies of the Children's Bureau*, published in the *Quarterly Publications of the American Statistical Association*, Vol. XVI, pp. 30-53, June, 1918.

were designed to meet these needs. They were commenced, indeed, at a time when no comprehensive data on infant mortality were available for the United States, since the publication of annual statistics of births and infant deaths for the birth registration area did not begin until 1915. Such figures as were at hand, which related to a few cities and States where birth and death registration were better enforced than elsewhere, indicated unnecessarily high rates. The object of these studies was, by grouping infants according to the contrasts in conditions which surrounded them during their first year of life, to show the causes of differences in infant mortality, and by a thorough analysis of all these conditions to ascertain in so far as possible the specific influence which each condition exerted upon the rate. With such information in regard to the causes of high and low mortality, proposals for preventive measures, it was believed, would not only be more effective in their appeal but would be more likely to accomplish worth-while results.

In making such a study certain problems had to be met,—problems of obtaining the data, of preparing it for analysis, and of analysing it so that sound conclusions could be reached. The validity of the conclusions depends not only upon technical sufficiency of the methods of analysis but also upon the accuracy of the original information used. A brief statement of the principal problems involved in obtaining this information and the methods adopted to meet them is, therefore, necessary to an intelligent evaluation of the results of analyses presented in succeeding chapters.

Since the studies were of the intensive rather than of

the extensive type, they were limited to a comparatively few cities which could be surveyed adequately with the means available. They involved a thorough study of the factors affecting the lives of all babies born during certain years, between January 1, 1911 and December 31, 1915, in these cities. Eight cities were eventually surveyed: Johnstown, Pa., Manchester, N. H., Saginaw, Mich., Brockton, Mass., New Bedford, Mass., Waterbury, Conn., Akron, Ohio, and Baltimore, Md.

A variety of social and industrial conditions characterized these eight cities. Johnstown was devoted to the manufacture of iron and steel and had a large foreign element principally of Slavic origin. Manchester and New Bedford were textile cities, one with a large French-Canadian and the other with a large Portuguese colony. Brockton was a shoe center; Akron's principal industry was rubber manufacturing, while that of Waterbury was brass manufacture. Saginaw and Baltimore had varied industries. Baltimore was the only city of the group which had a considerable Negro population, nearly 15 per cent of the total.

This series of inquiries did not include any farming or agricultural communities or even any small towns. For these omissions there were three reasons. In the first place, a survey of infant mortality in other countries indicated that, as a rule, mortality is much higher under urban than under rural conditions, and the few figures which were available for this country indicated that here, too, the cities have the higher rates.² In

² Of the 30 states in the birth registration area in 1923, in 9 the urban infant mortality rates were lower than the rural rates. In the original birth registration area, exclusive of Rhode Island, the urban

other words, the problem of infant mortality is most acute in the cities. In the second place, a study of mortality in different cities indicated wide variations in rates, while in rural areas variations were much less marked. The conclusion was immediately suggested that a study of conditions in certain cities which showed decided contrasts in industrial and social conditions and in the proportion and kinds of immigrant populations, might help to throw light on the causes of such variations. To these reasons a third was added, that in cities the work of surveying and studying the factors at work could be done more inexpensively and at the same time more thoroughly than would be possible for groups of equal size in rural districts.

The primary problem was that of how to secure the information. The obvious method of approach was to use the certificates of births and deaths, which gave at once names, dates, pathological causes of death as certified by the physician in attendance and information relating to many points which were important in a study of causes, such as sex of the infant, order of birth, whether single or plural birth, and age, race and nativity of the mother. This information was supplemented by data obtained by trained field agents in visits to each family. The inquiries of these agents covered type of feeding, earnings of father and of other members of the family, other sources of income, nationality (mother tongue), employment, and mater-

rate was below the rural, 78.1 as compared with 81.5. As pointed out in Chapter I, there is evidence of a tendency for the infant mortality rate to decrease more rapidly in the cities than in the country districts.

nity history of the mother, housing conditions, and other points. With the results obtained it thus became possible for the first time in this country to study and analyze the effects of these various factors upon mortality under one year of age.³

The second problem arose out of the difficulties encountered in securing the information. In some cases, for example, it was impossible to locate the family and hence the data needed for the analysis of causes which had to be added by personal interviews could not be obtained. In other cases it was ascertained that infants for whom either birth or death records were found had not lived in the city for more than a short period, or that they had not been born in the city, or that they (or their families) had moved away from the city and had died elsewhere at ages under one year. Furthermore, during the progress of visiting the families in a number of cases infants were discovered who had been born in the city during the period selected for the

³ As constituting a possible exception to this statement mention should be made of the study by the Bureau of Labor Statistics on Infant Mortality and its Relation to the Employment of Mothers, Vol. XIII of Report on Condition of Woman and Child Wage Earners in the United States, 61st Cong., 2nd Sess., Sen. Doc. No. 645. This study was in two parts, one a review of Massachusetts statistics which did not permit of more than unsatisfactory general correlations, and the other an inquiry into the causes of death of infants in Fall River, which was based upon deaths only. In this connection should be mentioned the study of infant mortality in Fall River based on births during June, July, and August, 1913, which covered several of the factors mentioned above. Dr. Louis I. Dublin, *Infant Mortality in Fall River, Massachusetts—a Survey of the Mortality among 833 Infants Born in June, July, and August, 1913*, in *Quarterly Publications of the American Statistical Association*, June, 1915, Vol. XIV, pp. 305–320.

study but whose births had not been registered. The problem was therefore raised, how should the data be treated so as to yield valid infant mortality rates for purposes of this analysis?

These difficulties were met by adopting a policy of exclusions. The cases excluded, which were not numerous, were omitted on the basis of definite principles so framed as to secure, though not the infant mortality rate for the city as usually calculated, a rate typical of the normal infant population of the city. Consideration of the nature of an infant mortality rate for a locality suggests the methods which were adopted.

An infant mortality rate is the probability of a live born infant's dying before his first birthday and is usually expressed as the number who die out of every thousand born. The usual method of calculating the rate for any city—a method which gives an approximate figure only—is to compare all deaths under one year of age in the city during a given year with all living births in the city during the same period. This method is open to the objection that the vital records of the city include some deaths of infants born elsewhere and some of infants born during the preceding year. Such a method could scarcely yield satisfactory results when the data were subdivided according to race, nationality, and economic status of father, since after subdivision the effect of the inaccuracies inherent in the method would tend to be increased and would be especially difficult to estimate.

Theoretically the correct method is to find, among the infants born in a given year, the number who died under one year of age. This latter method was adopted,

therefore, for the bureau studies. The family visits of the agents, which were necessary in order to obtain the additional information, made it possible to ascertain whether each infant born in the given year had survived its first birthday and thus furnished the information necessary for calculating the rate by this method.

Since to determine the infant mortality rate in any group it is only necessary to follow every infant in the group for one year after birth to ascertain whether he lived or died, any policy of exclusions will result in a satisfactory basis for the study of that group which fulfills the requirement that the infants who are included can be followed for one year after birth. Other things being equal, however, the more nearly the group selected represents the infants who are subject to the influences of the conditions in the particular cities the more significant will be the results of the analysis from the point of view of these conditions. The nature of the groups excluded, as discussed in the following paragraphs, sets forth the results of the policy of exclusions and throws light upon the significance of the final mortality rates. Five groups were excluded from consideration in the analysis: the infants who were known to have moved away from the city before the first birthday, those who could not be traced (nearly all of them probably also cases of removal), those born to non-resident parents, those of illegitimate birth, and a few for whom information was obviously inaccurate or incomplete.

Infants born in families which had moved away from the city within a year after the birth were excluded for

two reasons, first because, in most cases at least, the record of life or death was incomplete, and secondly because, even if these infants could have been traced to their first birthdays, during the period lived outside the city they were no longer subject to the influences characteristic of the city. Hence, even if all the necessary information could have been secured, to include them would have tended to obscure the analysis of the factors associated with the city conditions.

Most of the infants born in families which could not be traced doubtlessly would have been classed in the preceding group had complete information been available. In these cases the addresses on the birth certificates were no longer correct, and no information could be obtained either through neighbors or through the post office as to the whereabouts of the families. Nor could they be located in other parts of the city during the course of the survey. Although they could not in any case have been included because of entire lack of the information required for the analysis, if this information had been available it is safe to say that practically all would have been excluded for reasons of the same type as those for the exclusion of the first group.

Infants born to non-resident mothers were excluded not only because in most cases they did not live in the city during the whole of their first year of life, but also because the conditions surrounding their mothers before their births might have differed materially from those surrounding mothers who lived in the city. Furthermore, if many of these mothers had come to the city to avail themselves of the city's superior hospital facilities for confinement, exclusion of their

infants from the study was the more desirable because an undue proportion of them were probably subjected to difficult or complicated confinements,—a factor which would affect the mortality rate.

Infants of illegitimate birth were excluded partly because in most cases the conditions surrounding them were not normal family conditions and partly because the information for such cases was especially difficult to secure accurately. In many ways, furthermore, such a group requires separate treatment in analysis. A thorough study of the factors surrounding illegitimate infants involves an entirely different emphasis from that of the factors surrounding infants in normal families. Mention may be made, for example, of the importance of emphasizing whether the infant lives with his mother or is separated from her, and of ascertaining the amount of the contributions, if any, which the father makes to the support of mother and child. The exclusion of illegitimate births, in short, made the study one of a homogeneous group. In such a group the influence of the various factors at work would be much more clearly revealed than in one in which their effects might be obscured by the additional special influences affecting infants born out of wedlock.

A fifth group comprised a few cases which were excluded because the data obtained were unsatisfactory or were obviously unreliable.

The data available for analysis related, then, to the legitimate infants who had been born in the cities, during the years selected, who had lived there until their first birthdays or until death, whose families could be located and traced, and for whom information in

regard to the conditions under which they had lived or died was obtained. Except for the points to be noted immediately, all infants born in the cities studied during the years selected who met these requirements were included in the analysis.

The final difficulty remained, however, that the records of births and deaths which were used as a basis for the home visits might not be complete and, if not complete, that the omissions might be such as to constitute a biased selection. A complete list of all births and deaths which fulfilled the conditions already set forth would offer the best basis for study since, if all such births and deaths were included, no question of possible bias through selection could arise. Nor would the conclusions be affected if, in using such a list, omissions occurred merely at random. But if, as might frequently happen when registration was made the sole basis of selection of cases, more births than deaths were omitted, the infant mortality rate would be overstated. What provision could be made to prevent such biased errors?

Three methods of procedure were possible. The first was to take the registrations as they were, treating each death record as a birth record if the birth had actually occurred in the city. The second was to take the registered births as a starting point and accept a record of death only when the birth record also was available. The third was to supplement the registration records by further inquiries or by a canvass.

All three methods would give the same result if birth and death registration were complete, and the results of the three methods would differ in proportion

to the degree of incompleteness in the registration records. In determining the best method to follow, therefore, the character and extent of the omissions and the quality of the supplementary information available had to be taken into account.

The first method, to accept the records as they stood, would give satisfactory results if the records both of births and of deaths were complete. But if death registration was more complete than birth registration, the method would yield a biased or overstated infant mortality rate, for a case in which the birth had not been registered would be included only if it appeared on the list of deaths. In view of the doubt raised during the course of the studies as to the completeness of birth and death registration in the several cities, this method was not used in any study.

The second method sought to avoid the bias of the first by using birth registration as the sole basis for the selection of cases. Since birth registration must in general occur prior to death registration, a selection of cases in which the births were registered, in conjunction with the follow-up of each case through the visit of an agent, would yield a sample group of births in which the toll of deaths was complete and accurate.

Three of the studies of the bureau were made by the second method, that is, on the basis of registered births: those in Manchester, Brockton, and New Bedford. In all three places, but perhaps especially in Brockton and New Bedford, where special canvasses for unregistered births are made each year, birth and death registration are both unusually complete. Nevertheless, in each city a few cases were found in which the death

was recorded of an infant born in the city but whose birth was unregistered. In accordance with the principle mentioned above these were omitted and the study was based only on infants whose births were registered.

The third method involved assuming, in the absence of evidence to the contrary, that both birth and death registration might be faulty and attempting to remedy the defects in the original records by supplementary data. These data might be secured by one or more of various means, for example, by neighborhood inquiries, by examination of church baptismal rolls, or by a house-to-house canvass. If the means adopted for supplementing the data were adequate, the third method would avoid the doubt attaching to the selective feature of the second, since the final record would include all infants born in the city who were not comprised within one of the excluded groups.

The superiority of the third method was due to the fact that the omissions resulting from selection on the basis of birth registration might actually work out with a bias. Thus, in Saginaw, adequate data were available which made it possible to use either the second or the third method. The mortality rate secured by the second method for infants of foreign-born mothers in the lowest income group—infants whose births were recorded—was only 50 per 1000, or nearly as low as the rate for babies of native mothers of the highest income class; but when the infants located during the course of the canvass—infants whose births had not been registered—were added the rates were much more in accordance with those found in other cities. Evidently the infants of foreign-born mothers whose births had been

registered were not representative of the group as a whole but had a much more favorable mortality than that of infants of foreign-born mothers whose births had not been registered. The second method was perhaps satisfactory when the records were nearly complete, but the only satisfactory basis when many omissions occurred in the records was to endeavor to complete the list of births in order to avoid any element of selection.

In two cities the choice of method was limited in effect by the practice of the registration offices. In Waterbury and in Baltimore the registrars made it a rule, if the death was reported of an infant whose birth had not been registered, to look up the case in order to make sure that the child had been born in the city, and, if so, to have the birth recorded forthwith. In these cities, obviously, the second method was inapplicable and the only way to avoid the bias of the first method was to supplement the data in order to make them as complete as possible.

The third method, therefore, was used in all except the three studies mentioned above in which the second was followed.

The methods of supplementing the data varied in the different cities and became more and more adequate as the studies progressed and as the need for completing the roll of births and deaths became more fully realized. Thus in Johnstown, the city first studied, the list of registered births was supplemented only by the list of baptisms and by neighborhood inquiries, especially in the Servian quarter of the city where the home visits of the agents indicated that the births had not all been

registered. In Saginaw the deficiency in birth registration was early appreciated, and special efforts were made to add to the list by means of neighborhood inquiries, examination of church baptismal records, and in other ways. As a result 141 infants were added to the total of 1,065 registered live births. In Waterbury, 329 unregistered were added to the 2,239 registered live births by similar measures supplemented by a house-to-house canvass. In Akron a complete house-to-house canvass of the city was made; and the results were compared with the list of registered births and with records of baptisms; the number of unregistered infants found by these means formed 13.7 per cent of the total. In Baltimore a vigorous campaign for improved registration was in progress during the year selected for study and many names were added to the lists of registered births not only as a result of the activities of the bureau agents who were visiting the homes, but also through many other agencies which were coöperating with the health department to improve registration.

The purpose of the canvasses and other means of supplementing the records of births and deaths was not primarily, it should be emphasized, to ascertain the proportion of omissions in these records; it was rather to supplement and complete the list of those infants who belonged to the group to be studied, i.e., who had been born in the city during the selected year and who did not fall in any of the excluded groups. In other words, no effort was made to learn of infants born in the city during the selected year who had moved away; such cases would not in any event have

been eligible for inclusion in the study. In addition, indeed, to the other reasons mentioned for the exclusion of migratory families this exclusion was justified because it fitted in with the plan of securing additional information by means of a canvass. If the group to be studied included only cases in which the infant was born during the year selected and the family was living in the city at the time of the canvass, it would be possible by means of a thorough canvass to locate all infants that ought to be included.

In accordance with these methods, then, the records for nearly 23,000 live born infants were collected and tabulated. These formed the basis for the bureau's studies and for the conclusions which are set forth in the following chapters. But in order that the validity of these conclusions may be judged, attention must be paid not only to the methods of collection of the original data but also to the methods of analysis to which such complicated materials have to be subjected if the various factors which together produce the general infant mortality rate are to be disentangled and the influence of each factor is to be determined. In the two next following chapters these methods of analysis and the need for them will be discussed.

CHAPTER III

PROVISIONAL RESULTS

Following the methods described in the preceding chapter a total of 22,967 live births which fulfilled all the conditions of the Children's Bureau study were found in the eight cities. For each of these infants information was obtained as to the economic and social conditions under which he lived during the first year or until death. With this information it became possible to study the influence of many factors which were not included in the data available from birth and death records and to study them with a refinement of analysis to which the latter records do not lend themselves. In the present chapter the preliminary results obtained by a simple classification of the data are set forth, together with a brief statement of the reasons why a more detailed analysis was necessary before final conclusions could be reached.

The infant mortality rate for the entire group of 22,967 live births was found to be 111.2. In other words, out of every thousand infants born alive about 111 died under one year of age. This rate of itself is without significance except for purposes of comparison with other data. Comparing it with the average rate (103.3) for the cities of the birth registration area in 1915 indicates that the infants in the selected cities were exposed to conditions slightly more unfavorable to survival than those which prevailed on the average in all the cities of the area. But the comparisons which

are of most significance are not those between the rate for the group as a whole and figures for any other group, but those between the rates for various subdivisions of the total number of infants studied in each of which the babies were subject to some special condition. It is with these latter comparisons that the following analysis is concerned.

The great majority—nearly four-fifths—of the deaths were classified in three principal groups of causes of infant mortality, causes peculiar to early infancy, gastric and intestinal diseases, and respiratory diseases. Causes peculiar to early infancy were responsible for nearly one-third of all the deaths, and had a rate of 36.1; this rate was composed of 17.4 from premature birth, 14.9 from congenital debility, and 3.8 from injuries at birth. To a large extent these causes have their origin in the condition and care of the mother during pregnancy and confinement. Gastric and intestinal diseases held second place with a rate of 32.4, which included rates of 1.0 from diseases of the stomach and 31.3 from diarrhea and enteritis. These deaths are due largely to improper feeding. Respiratory diseases ranked third with a mortality of 19.6, including rates of 3.0 from bronchitis, 11.6 from broncho-pneumonia, and 4.9 from pneumonia. Epidemic and other communicable diseases caused a mortality of 7.1, of which whooping cough took the largest single toll with a rate of 2.1, though the same rate appeared for the miscellaneous group of “other” so-called epidemic diseases; the figure for tuberculosis in its various forms was 1.6, and that for syphilis was 1.0. Malformations accounted for a rate of 4.3, external causes for one of

0.6, other defined diseases for one of 8.7, including meningitis with 1.4, convulsions with 2.0, and organic diseases of the heart with 0.4, and ill-defined diseases for one of 2.5.

So much for the facts regarding the pathological causes of deaths. What were the underlying causes of this mortality? In many cases the pathological causes point directly to the underlying causes. Thus mortality from injuries at birth immediately suggests inadequate or inefficient confinement care; deaths from premature birth suggest conditions which produce or favor prematurity; and deaths from congenital debility, in so far as this cause does not appear merely because of poor diagnosis by the physician who signed the death certificate, suggest hereditary weakness, or lack of vitality caused either by disease transmitted from the parents or by inadequate care of the mother during her pregnancy. Deaths from diarrhea and enteritis, too, suggest immediately faulty feeding, lack of cleanliness in connection with artificial food, or failure to have proper medical supervision over the care of the infant. Similarly other pathological causes might be traced back to more or less definite underlying causes. These underlying causes furnish the chief interest in the present study since a knowledge of them is necessary if adequate and effective preventive methods are to be devised and adopted.

A preliminary survey showed a number of factors each of which might apparently have a close connection with infant mortality. These included age of the infant; seasonal conditions; sex; factors related to the health and physical condition of the mother during

pregnancy and at confinement; factors related to frequency of births—age of mother, order of birth, interval since preceding birth, and interval before succeeding pregnancy; factors associated with birth or confinement,—including prematurity, single or plural birth, and type of delivery; types of feeding; racial or nationality factors; and social and economic factors including, in addition to housing conditions, earnings of the father, per capita income of the family, and employment of the mother during pregnancy or during the infant's first year of life.

The age of the infant appeared to exert a powerful influence. During the first month of life the monthly death rate per 1,000 living at the beginning of the month was 44.8, but it dropped to 9.3 in the second month and later fell more slowly to 4.5 in the twelfth—less than half as high as in the second month (table 6).

Marked variations were found in the number of deaths from most of the pathological causes during the different seasons. The mortality from gastric and intestinal diseases, for example, was at a maximum in August, when it was 13 times the minimum, which occurred in January. The highest mortality from respiratory diseases, on the other hand, was found in February, when it was 7 times the lowest figure, which occurred in August. Deaths from epidemic and other communicable diseases were more frequent in the late winter and early spring than in the late autumn and early winter.

When the infants were classified according to month of birth, it was found that those born in August had the lowest and those born in June had the highest

rates of mortality. Since the variations in seasonal incidence were greater for gastric and intestinal diseases than for other groups of causes of death the differences in the mortality rates for infants born in different months were determined largely by the relation which the month of birth bore to the infant's age when exposed, during the summer following the birth, to the heaviest incidence of these diseases.

TABLE 6
Mortality rates by age of infants

MONTH OF LIFE	MONTHLY MORTALITY RATES	ANNUAL MORTALITY RATES*
First.....	44.8	538
Second.....	9.3	112
Third.....	8.1	97
Fourth.....	8.0	96
Fifth.....	7.7	92
Sixth.....	7.4	89
Seventh.....	6.3	76
Eighth.....	5.8	70
Ninth.....	5.7	68
Tenth.....	5.3	64
Eleventh.....	3.9	47
Twelfth.....	4.5	54

* If rates for each month had continued for twelve months.

A sex classification showed that the mortality among the boy babies was about one-fourth higher than that among the girls, 123.0 as compared with 99.1. And this excess mortality among the boys was found for nearly every cause of death.

Perhaps first in importance of the underlying causes of these infant deaths, though not one concerning which sufficient data could be obtained, was lack of health and

physical vitality in the mother during pregnancy and at confinement. The information on these subjects in the present studies was limited to comparatively few points; and on only one of these points, the correlation between the mother's death within one year after the birth and the infant's survival or death at the first birthday, was information obtained for all eight cities. But for one city, Baltimore, data were available on three additional points, the relation of infant mortality to tuberculosis of the mother, to convulsions appearing as a symptom during the mother's pregnancy, and to medical prenatal care.

Infants whose mothers died within one year following the confinement appeared to be subject to a considerable handicap, for their mortality rate, 450.0 per 1,000, was over 4 times as high as that for other infants, 109.2. In those cases in which the mother died within one month after confinement the mortality was even higher. Six in every ten of these babies died before the end of the first year.¹

Infants whose mothers were known to have had tuberculosis had a mortality (271) two and one-half times as high as that (102) among other infants.

Over one-third of the 42 babies born to mothers who were reported to have had convulsions as a complication of pregnancy died during the first year of life.

The infant mortality rate of infants whose mothers were reported to have had medical prenatal care—consisting either of one or more visits or consultations with a physician, or of one or more urinalyses, or both, a very modest minimum requirement—was decidedly

¹ In this connection, see Appendix, p. 180.

lower, 93.8, than that of those whose mothers had had no prenatal care, 113.3.

A second group of factors in infant mortality, and one upon which the present material throws more light, comprises those which together make up the influence associated with frequency of births, that is, age of mother, order of birth, interval since preceding birth, and interval before succeeding pregnancy.

TABLE 7
Infant mortality rates, by age of mother

AGE OF MOTHER	INFANT MORTALITY RATES
Total.....	111.2
Under 18 years.....	160.3
18 to 19 years.....	128.9
20 to 24 years.....	109.5
25 to 29 years.....	101.4
30 to 34 years.....	104.7
35 to 39 years.....	126.5
40 to 44 years.....	131.3
45 years and over.....	(250.0)*

* Based on only 44 cases.

The age of the mother at the time of the baby's birth appeared to exert an important influence upon infant mortality, which was much higher for the youngest and also for the oldest mothers than for those of intermediate ages (table 7). The death rate for infants whose mothers were under 18 years of age was 160.3; for those whose mothers were between 25 and 29 the rate reached its lowest point, 101.4; and for those whose mothers were between 40 and 45 it was

131.3, while for the small group over 45 years of age a very high rate, 250, was indicated.²

Order of birth also appeared to have a marked influence upon infant mortality. According to table 8, the rate for first babies was slightly higher than that for second, 104.6 as compared with 95.7; after the second child the rate rose gradually with increasing orders of birth until it reached 181.5 for the group tenth and later.³

TABLE 8
Infant mortality rates, by order of birth

ORDER OF BIRTH	INFANT MORTALITY RATES
Total.....	111.2
First.....	104.6
Second.....	95.7
Third.....	104.6
Fourth.....	108.8
Fifth.....	118.8
Sixth.....	122.7
Seventh.....	136.8
Eighth.....	135.9
Ninth.....	146.8
Tenth and later.....	181.5

The interval since the preceding birth appeared to exert an influence upon mortality when it was relatively short, that is less than one or two years. Interval was measured by comparing the mother's age at the time of the scheduled birth with her age at the time of the preceding birth; when the difference between these ages, expressed in even years, was one year the rate of infant

² For further analysis of this factor, see below, pp. 69 and ff.

³ For further discussion of this factor, see below, pp. 65 and ff.

mortality was 146.7, as compared with only 98.6 when the difference was two years and with 86.5 and 84.9 when the difference was three years and four or more years (table 9). Lack of proper spacing of births thus appears to affect unfavorably the infant death rate.

A short interval before a succeeding pregnancy likewise appeared to exert an influence upon infant mor-

TABLE 9
*Infant mortality rates, by interval since preceding birth**
Based on births in Baltimore

INTERVAL SINCE PRECEDING BIRTH*	INFANT MORTALITY RATES
Total.....	103.5
First.....	94.8
Second and later births.....	106.6
Interval 1 year.....	146.7
Interval 2 years.....	98.6
Interval 3 years.....	86.5
Interval 4 years and over.....	84.9

* As measured by the difference in even years between the mother's age at the time of birth of the scheduled child and her age at the time of the preceding birth.

ality, although in this case only a comparatively small proportion of all the infants were subjected to such a condition. The information on this point was limited to a single city, Baltimore. In about 11 per cent of the total number of cases of live births the mother became pregnant during the infant's life and before he had passed his first birthday. But only 4.7 per cent of the total number of months lived by all

infants during the first year were lived after their mothers had become pregnant. The possible contribution of this factor to the general mortality rate, therefore, was comparatively slight. Nevertheless, among these infants nearly three times as many deaths occurred as would have been expected at the average rates for all infants at the same ages, 75 instead of 27 deaths.

Factors associated with the birth or confinement which may be considered as underlying causes of infant mortality included prematurity, single or plural birth, and type of delivery.

The babies who were prematurely born had a mortality rate six times as high as that of the babies who were born at term. Almost half these babies died during their first month.

Twins and triplets also were subject to a very high mortality, for the death rate among them, 363 per 1,000, was nearly three and one-half times that among single-born infants.

Infants whose mothers were delivered by means of instruments had a mortality rate of 120.3, considerably higher than the rate for other infants, 102.1. As perhaps would be expected, the higher mortality was confined almost wholly to the causes included under the term "injuries at birth."

A more important, because more common, underlying cause of infant deaths was found in the character of food given to babies. The mortality among the artificially fed was between three and four times as high as that among the breast fed infants.⁴

⁴ For detailed discussion see Chapter V.

Marked variations were found in the mortality rates for the various nationalities (table 10). The babies of Jewish mothers had the lowest rate, 53.5, while those of Portuguese mothers had the highest, 200.3. The rate for colored was nearly one and one-half times that for white. The rate for babies of native white mothers, 93.8, was considerably less than that for babies of foreign-born mothers, 127.0.⁵

TABLE 10
Infant mortality rates, by color and nationality of mother

COLOR AND NATIONALITY OF MOTHER	INFANT MORTALITY RATES
Total.....	111.2
White.....	108.3
Native.....	93.8
Foreign born.....	127.0
Italian.....	103.8
Jewish.....	53.5
French-Canadian.....	171.3
German.....	103.1
Polish.....	157.2
Portuguese.....	200.3
Other.....	129.6
Colored.....	154.4

Marked differences were found also in the mortality among infants living in different degrees of housing congestion. According to table 11, the rate was highest, 135.7, for infants born in families which lived two or more persons per room, and lowest for infants born in families which lived less than one person to a room.

⁵ For detailed discussion see Chapter VI.

Infants whose mothers were employed away from home during pregnancy had a mortality rate, 176.1, very much higher than the rates either for infants whose mothers were employed at home, 114.6, or for

TABLE 11

Infant death rates, by average number of persons per room
*Infants in seven cities who survived two weeks**

AVERAGE NUMBER OF PERSONS PER ROOM	INFANT MORTALITY RATES
Total.....	75.7
Less than 1.....	52.1
1, less than 2.....	94.9
2 and over.....	135.7

* Excluding a small number of infants (Baltimore) who did not live two weeks in dwelling of residence.

TABLE 12

Infant mortality rates, by employment of mother during pregnancy
Live births in eight cities

EMPLOYMENT OF MOTHER DURING PREGNANCY	INFANT MORTALITY RATES
Total.....	111.2
Employed away from home.....	176.1
Employed at home.....	114.6
Not employed.....	98.0

those whose mothers were not employed at all, 98.0 (table 12).

Babies whose mothers were employed away from home during their first year of life—a group which comprised 7.6 per cent of the total number of infants—appeared to have a mortality two and one-half times as

high as the average prevailing at the ages which they had reached when their mothers were at work. On the other hand, infants whose mothers worked at home appeared to experience about average mortality.

An analysis by father's earnings indicated that the higher the father's earnings the lower was the infant mortality. Infants whose fathers earned less than \$450 had a death rate of 166.9 (table 13), as compared

TABLE 13
Infant mortality rates, by earnings of father
Live births in seven cities

EARNINGS OF FATHER	INFANT MORTALITY RATES
Total.....	110.0
Less than \$450.....	166.9
\$450 to \$550.....	125.6
\$550 to \$650.....	116.6
\$650 to \$850.....	107.5
\$850 to \$1,050.....	82.8
\$1,050 to \$1,250.....	64.0
\$1,250 and over.....	59.1
No earnings.....	210.9

with a rate of only 59.1 for infants whose fathers earned \$1,250 or over. The rate for the babies whose fathers were reported to have had no earnings during the year following the births was highest of all, 210.9.⁶

When the figures were analyzed according to per capita income from father's earnings in table 14, the same striking relationship was shown between high rates and low income and comparatively low rates and

⁶ For detailed discussion see Chapter VII.

high income. In families in which the per capita income from father's earnings was less than \$50 the infant mortality rate was 215.9, as compared with a rate of only 60.5 in families in which this per capita amount averaged \$400 or over.

These findings must be considered, however, simply as the preliminary conclusions to which the figures point when each factor is considered without reference

TABLE 14

Infant mortality rates, by per capita income as measured by average earnings of father per capita of household

Live births in seven cities

PER CAPITA INCOME FROM FATHER'S EARNINGS	INFANT MORTALITY RATES
Total.....	110.0
Less than \$50.....	215.9
\$50 to \$100.....	141.8
\$100 to \$200.....	123.2
\$200 to \$400.....	96.1
\$400 and over.....	60.5
Not classified:	
Fathers' earnings \$1,250 and over.....	59.1
No fathers' earnings.....	210.9
Earnings not reported	139.7

to other factors. Before a final conclusion can be drawn as to the real influence which any of these factors exerted, the material must be subjected to further analysis. An illustration or two will make this point clear and will show the type of analysis which is required.

In regard to the high mortality found among the prematurely born, for example, analysis indicates that a much larger proportion of these babies than of

those born at term were twins and triplets. But the death rate for all the twins and triplets was also unusually high. The questions are thus raised, was the high mortality among the prematurely born due to the high mortality among the twins and triplets, or was the latter due to the former, or what influence had each upon the other? These questions are not difficult to answer, at least in general terms. On the one hand, the relatively high mortality among the prematurely born, as compared with that among full-term infants, was shown to be independent of the high mortality among the twins and triplets by the fact that the mortality among the premature single infants was much greater than that among the full-term single infants. And the relatively high mortality among the twins and triplets, as compared with that among the single born infants, was shown to be independent of the high mortality among the prematurely born by the fact that the mortality among the full-term twins and triplets was much greater than that among the full-term single-born infants.

But the further question may be raised whether the relatively high mortality among the premature infants was not due in part to the fact that a larger proportion of them than of other infants were artificially fed. And also, did the fact that a somewhat larger than average proportion of premature babies were boys exert an appreciable influence over their high mortality? These are questions which must be considered before we can determine finally what was the influence of prematurity, as distinguished from that of the various other factors associated with it.

Anticipating at this point the results of the analysis, it

may be stated that even after allowance was made for the undue proportion of twins and triplets among the prematurely born, they had a mortality which averaged 5.13 times that for the full term infants, as compared with 6.14 times before such correction was made. And so far as the undue proportion of males was concerned correction for this factor produced only a negligible change in the ratio, from 6.14 to 6.10. But when allowance was made for the influence of type of feeding, by comparing the rates for the premature and the full term babies among the breast fed, the partly breast fed, and the artificially fed respectively, the mortality among the premature appeared to be only 4.3 times as high as that among the full-term infants. In this comparison, however, a considerable number of infants were left out of account because they died before they were fed. The mortality among the premature during the first few days after birth was 31 times as high as that among the full-term infants; and when the babies who were fed and those who were not fed were combined, the average mortality among the premature appeared to be slightly over 8 times as high as that among the full-term infants. Without laying too much emphasis upon the exact ratios between the rates for the two groups, it is plain that prematurity is associated with definitely adverse conditions which are not to be explained by its correlation with plural births, with sex, or with a greater prevalence of artificial feeding. It is also clear that this type of analysis is capable of showing how important or how unimportant are such correlated factors in producing the influence which might be ascribed solely to a particular factor such as prematurity.

The more complex the social causes to be considered the more difficult, of course, becomes such an analysis. The question of the effect upon infant mortality of the employment of the mother in the year following the birth of the infant offers an example. Among the 1,742 infants whose mothers were gainfully employed away from home in the eight cities 168 deaths occurred after the mothers' resumption of work. If the rates for all babies of the same ages had prevailed for these infants from the time the mothers resumed work until the end of the first year of life, only 68 deaths would have resulted. In other words, the mortality among the babies whose mothers were gainfully employed during their first year was over twice the average rate.

Was this excess mortality due to the necessity for artificial feeding? Was it due to any preponderance in this group of infants of colored mothers or of infants in the low income groups? Does the increased care made possible by the added income of the gainfully employed mothers offset the decreased care resulting from her absence at work?

The analysis indicated that a slight preponderance of colored and a considerable preponderance of infants in the low income groups accounted for part of the high mortality among the babies whose mothers were employed. But even after allowance was made for both these factors their mortality was found to be 1.4 times the average.⁷ A considerable part, but not all, of

⁷ Since in this analysis the income from the fathers' earnings only is used, the benefit, if any, from the increased income from the employment of the mother is reckoned to the extra credit of the infants of the employed mothers: the excess mortality among them as stated was, therefore, found in spite of such credits.

this excess was accounted for by the high proportion of cases in which artificial food was given; but the tendency to artificial feeding was doubtless itself causally connected with the mothers' absence from home on account of work. The evidence suggests, therefore, that the babies suffered from the mothers' absence on account of work in other ways than by losing the benefits of being breast fed.

These problems clearly point to the need for a method of analysis which disentangles the various causes. This subject is treated more at length in the next chapter, which is devoted to an exposition of the "Method of Expected Deaths" for disentangling interrelated causes developed by the distinguished Danish statistician, Professor Harald Westergaard. In that chapter the discussion is illustrated by an example in which the method is applied to the analysis of a group of closely interrelated factors—mother's age, order of birth, and interval between births. In the later chapters, also, the method is used to isolate the influence of each of several factors.

It may clarify the later discussion, however, if at this point the conditions are briefly stated under which it is necessary to consider eliminating the influence of one or more disturbing factors. For example, is it necessary to correct the conclusion that the mortality among male infants is greater than that among female infants for possible disturbing influences of prematurity, of economic conditions, or of, say, variations in atmospheric pressure? A correction is necessary provided that two conditions are both fulfilled: (1) that the suggested element is a factor—i.e., that it produces an

effect upon the infant mortality rate—and (2) that it has a disturbing influence upon or is correlated with the factor under consideration. The correction is the more necessary the greater is the effect of the particular factor upon mortality and the more closely it is correlated with the factor under consideration. In the example given above, there is no evidence that ordinary variation in atmospheric pressure is a “factor” in infant mortality nor is there any evidence that it is correlated with the sex of the infant: it may, therefore, be dismissed. Economic conditions have been shown above to be *prima facie* a factor in infant mortality, but the evidence does not show that there is any greater excess of boys in poor than in rich or comfortably well-off families or that the proportion of the sexes varies with economic conditions; this factor may likewise, therefore, be dismissed. On the other hand, the third element, prematurity, is not only definitely a factor in infant mortality, but evidence shows that a slightly larger proportion of males than of females are prematurely born. In this case, therefore, both conditions are present which require a correction of the preliminary conclusions as to the relative mortality among male and female infants.

The method of expected deaths for disentangling interrelated causes shows whether such a correlation exerts a marked or only a slight influence; in passing it may be remarked that in the case under discussion the analysis indicates that the influence of this correlation of sex with prematurity affected only very slightly the relative mortality among males and females.

Before passing to the more detailed consideration of the method of expected deaths to which the next

chapter is devoted, another problem of considerable importance may be briefly discussed, namely, the problem of determining how many cases suffice to establish a conclusion. In the example cited above, is the fact that 168 deaths occurred, instead of the 68 which would have been expected, among the 1,742 infants whose mothers were employed away from home during their first year of life a sufficient basis for concluding that the employment of the mother exercises an adverse influence over infant mortality?

The problem may be stated in slightly different words: Is the result due to some significant cause or causes or is it to be explained merely as a chance combination of insignificant or unimportant causes? If it can be shown not to be explicable on the ground of "chance combination of individually unimportant causes" a long step has been taken toward establishing the true causal connection, though the cause alleged may or may not prove after analysis to be the important causal factor that it appears. The procedure is simply to calculate the probability or improbability of the result occurring by chance. The proposition might be put as follows: If a very large number of black and white balls are mixed so that out of every 1,742 balls 68 will be black and if, then, 1,742 balls are drawn at random, the most probable number of black balls will be 68. How frequently would the number of black balls be as many as 168? It can be shown mathematically that such a result is extremely improbable—that it would occur probably but a few times in millions of drawings. One may conclude, therefore, reverting to the problem under discussion, that some significant causes were acting to increase the mortality

of the infants whose mothers were employed away from home and that there is a causal connection of some kind between infant mortality and mother's employment.

The problem is more complicated when it is desired to test the probability that the combined result shown in several groups simultaneously might be due to chance. For example, what is the chance that the trend of the figures in table 13, showing the relation between infant mortality and fathers' earnings, might be produced by a fortuitous combination of individually insignificant causes? For the single group, less than \$450, the chance that the rate of 166.9 would occur as a chance variation from the general average rate of 110.0 is, according to the mathematical formula of chance, extremely remote; the number of deaths in the group was 515, as compared with 339 expected at the average rate, and the probability of so considerable a deviation occurring by chance is but a few times in millions of cases. But the evidence in this case is not confined to the single group. Each group the rate for which falls in with the trend line contributes to the weight of the evidence that no mere chance elements could produce this result. Indeed, when such a series of rates is based upon a reasonably large number of cases, the common sense acceptance of the correlation as due to significant rather than purely chance causes is likely to be borne out by the abstruse mathematical calculations necessary to establish the exact probabilities. And, in general, the calculation of such probabilities is likely to be misleading rather than helpful, since it tends to divert attention from the need for interpreting correlation in terms of real causes.

CHAPTER IV

DISENTANGLING THE CAUSES¹

In a method of analyzing data, such as those of infant mortality, in which many and varied causes are at work to produce the given results, a prime requisite, as already noted, is that it shall permit of separating out and determining the influence of each factor when other conditions or factors are held constant. This requisite is possessed by Professor Westergaard's method of expected deaths used in conjunction with multiple classification. The purpose of this chapter is both to present the mode of applying that method to infant mortality data, and to give certain results of applying it to the data gathered by the United States Children's Bureau. It may be remarked in passing that the method, which is used also in later chapters, may be applied as effectively to many other problems.

In relation to each factor in infant mortality three questions are always pertinent—the questions of causal influence, of prevalence, and of the contribution which the factor makes through both its prevalence and its causal influence to the general result. Thus, with respect to single and plural births, the first question is whether twins and triplets have a greater mortality than single births; the second, what proportion

¹ Adapted by permission from an article entitled Westergaard's Method of Expected Deaths as Applied to the Study of Infant Mortality, published in the Quarterly Publications of the American Statistical Association, Vol. XVIII, pp. 366-376, September, 1922.

of the total births are plural; and the third, do twins and triplets contribute a large quota to the infant deaths? The answer to the last question obviously depends upon the answers to the other two. The first and third questions are often confused, as in the inquiry: Is the mother's employment an important factor in infant mortality? This is capable of two interpretations, one—of greater importance in an analysis of causes—relating to relative mortality, i.e., whether infants whose mothers are employed are subject to a higher rate of mortality than infants whose mothers are not employed, and the other relating to the amount of contribution to the total mortality, i.e., whether any excess mortality among infants of employed mothers in connection with a large or small prevalence of mothers' employment results in an important contribution to infant mortality. This question is of secondary importance since the contribution is the resultant of two primary elements. The method of analysis should distinguish between these primary and secondary elements in the problem. In other words it should distinguish between "causal" factors and "prevalence" factors. The present analysis is concerned primarily with the "causal" factors.

The first recourse in analysis is usually to that universally applicable method, simple classification, which has been used in the preceding chapter. If births and deaths are classified each by the same factors, such as earnings of father or nationality of mother, the rates of mortality indicate whether the factors used in the classification can be considered as having *prima facie* an influence upon infant mortality. But the results of

this form of classification, as suggested in the preceding chapter, must be regarded as tentative and subject to modification in case the factor under consideration is correlated with other factors.

The obvious next step in analysis is to include the correlated factors in the classification, which may then be termed "multiple classification." If two factors, such as earnings of father and nationality of mother, are found to be correlated,—that is, if certain nationalities have a much larger proportion of infants in families the fathers of which earned relatively low amounts,—the births and the deaths must be subclassified; the rates by earnings of father in each nationality group indicate whether earnings of father can be considered a factor independent of nationality, and the rates by nationality of mother in each earnings group indicate whether nationality of mother can be considered a factor independent of earnings. Evidently by this mode of comparison the effect of one factor upon the rate can be studied by the simple device of studying its influence in a group within which another factor does not vary.

Multiple classification, if carried far enough, possesses the essential requirements for isolating the effect of a single factor.² But as more and more classifica-

² In mathematical terms, assuming that all causal factors can be expressed numerically, the infant mortality rate, X_1 , can be stated in terms of its several independent causal factors: $X_1 = f(X_2, X_3, X_4 \dots X_n)$ where X_2, X_3 , etc., are the independent causal factors. The partial derivative of X_1 with respect to any one factor, for example, $\frac{\delta X_1}{\delta X_2}$, measures the change in X_1 due to the change in X_2 ; in other words, measures the influence of X_2 .

tions are introduced, on the one hand the results become increasingly difficult for the mind to grasp, and on the other, the material becomes more and more subdivided until, finally, the base becomes too small to ensure valid conclusions. To avoid the first of these difficulties, recourse may be had to the familiar process of selection of data. For example, the influence of varying prevalence of plural births may be eliminated by confining the analysis to single births, and the influence of differences in types of feeding may be eliminated by further omitting all except breast-fed infants. But to obviate the difficulty that the numbers in the final group may not be large enough to ensure valid results, a method of summation must be employed.

To avoid these difficulties in the use of the method of multiple classification recourse may be had to the method of expected deaths developed by Professor Harald Westergaard.³ This method, in fact, offers a simple and easily applicable way of isolating the influence of a single factor from that of other associated factors, and of stating the results in clear and definite terms.

Because the wide applicability of the Westergaard method seems not to be generally appreciated in this

upon X_1 when all other variables are considered constant. Geometrically, this partial derivative is the slope of X_1 measured along the axis of X_2 . In a classification table, for example, table 19, values of X_1 are given for different values of X_2 , with other factors, so far as they are included in the classification table, constant.

³ *Die Lehre von der Mortalität und der Morbilität: Anthropologisch Statistische Untersuchungen.* Jena. G. Fischer, 1882, pp. 28-30; and "Scope and Method of Statistics," *Quarterly Publications of the American Statistical Association*, Vol. XV, No. 115, September, 1916, pp. 260-64.

country, it will be described briefly before returning to the subject of its application to a specific infant mortality problem. Though designated as the "method of expected deaths" on account of its first application to mortality data, it is not restricted in its application to these problems but can be applied to a great many other fields, and in these fields it might be termed the method of "expected cases," or, generally, "expected results." The essence of the method lies in so calculating the expected numbers that a comparison between them and the actual numbers will be free from the disturbing influence of one, two, or several factors. By this means the effect of a single cause is isolated from the influence of other causes.

The best known, as well as the earliest, applications of the method were to the problems of eliminating variations in age and sex composition in comparisons of mortality rates in urban and rural populations and of eliminating variations in age composition in comparisons of occupational mortality.⁴ Since, in these appli-

⁴ The method of standardizing or correcting death rates for differences in age composition was clearly set forth in the introductory chapter of *Die Lehre von der Mortalität*, pp. 28-30. In England, in the Registrar-General's Report for 1882, this method of correcting for varying age composition in comparisons of urban and rural districts was used. (Forty-fifth Annual Report of the Registrar-General of Births, Marriages, and Deaths in England, Abstracts of 1882, C-4009 London, 1884.) The use of corrected death rates for Hamburg by Koch in 1883 is mentioned by Von Mayr, *Statistik und Gesellschaftslehre*, Vol. II, p. 219. Westergaard himself mentions the use of the method of expected deaths by Ratcliffe, in a first report, *Observations on the Rate of Mortality and Sickness amongst Friendly Societies*, Manchester, 1850, quoted in *Die Lehre von der Mortalität*, p. 287.

cations, identical or "standard" rates were applied to varying populations, or varying rates to identical or "standard" populations, the method is perhaps better known to English and American statisticians as the method of standards. But there is this difference: the name "method of standards," by suggesting that any standard is equally good, has sometimes led to the use of a standard that was not adapted to the particular problem; while the "method of expected cases," by comparing expected with actual numbers, always keeps as close as possible to the actual problem under consideration.⁵

With this preliminary statement, we may proceed to a study of the actual operation of the method in which its merits and its limitations will be revealed much more clearly than by mere description. The first question chosen to illustrate the operation of this method of expected deaths is that of determining the influence of order of birth upon infant mortality.⁶ Order of birth is closely associated with age of mother, since a large proportion of the births of later orders are to the older mothers; it is also correlated to some extent with the prevalence of twins and triplets; and it is correlated slightly with low income, since larger families as measured by the number of births are more prevalent at the lower income levels.

Table 15 presents a distribution of live births classi-

⁵ Compare the recent discussion of the best methods of choosing weights in the problem of measuring price increases—one of the familiar examples of the method of standards.

⁶ For a similar application of the method to this problem see Westergaard, *op. cit.*, Revised ed., 1901, pp. 371-75.

fied by age of mother and order of birth.⁷ An inspection of the distribution shows at once that the lower orders of birth are associated with the younger ages and the higher orders with the higher ages. The infant mortality rates for the order of birth groups beginning with first births are 104.7, 95.7, 104.6, 108.8, 118.8,

TABLE 15
Age of mother and order of birth
Live births in eight cities

ORDER OF BIRTH	LIVE BIRTHS						
	Total	Age of mother					
		Under 20	20-24	25-29	30-34	35-39	40 and over
Total.....	22,967	1,584	6,879	6,618	4,231	2,688	958
First.....	6,230	1,227	3,125	1,349	399	114	14
Second.....	4,954	311	2,196	1,621	599	204	22
Third.....	3,328	39	968	1,407	609	260	45
Fourth.....	2,481	5	412	1,043	694	268	57
Fifth.....	1,767	2	133	624	631	306	69
Sixth.....	1,263		32	339	480	326	85
Seventh.....	921		9	138	353	320	101
Eighth.....	677		3	68	226	289	91
Ninth.....	470		1	20	126	224	98
Tenth and later.....	876			9	114	377	376

122.7, 136.8, 135.9, 146.8, and for tenth and over, 181.5. It may be noted that the rate for first births is higher than that for second, and that there is a rapid

⁷ The material is for live births in selected years in eight cities studied by the Children's Bureau, and is taken from Causal Factors in Infant Mortality, Bureau Publication No. 142.

increase in rate from 95.7 for second to 181.5 for births tenth and later in order. The average rate for births of all orders is 111.2; expressing this average as 100, the following numbers show the variation in rates by order: 94.2, 86.1, 94.1, 97.8, 106.8, 110.3, 123.0, 122.2, 132.0, 163.2. The rates for age-of-mother groups are: Under 20, 135.7; 20-24, 109.3; 25-29, 101.4; 30-34, 104.7; 35-39, 126.5; and 40 and over, 136.7.

In view of the fact that the infant mortality rates among births to older mothers are high and that these are largely births of the later orders, the question arises whether the age of mother is the factor that produces the high rate among the births of later orders, whether the order of birth is itself the causal element, or whether both factors contribute to the result.

This question can be answered by ascertaining what the rates by order of birth would have been on the assumption that age of mother is the sole causal factor, and comparing the actual with these calculated rates. Applying the average rates by age of mother to the distribution of births by order of birth and age of mother, the deaths in each sub-group can be calculated; the deaths in each order-of-birth group can then be added, and these totals compared with the actual deaths that occurred. If order of birth has no causal influence aside from its correlation with age of mother, the number of actual and of expected deaths will be equal. If, however, the actual deaths do not equal those expected, the influence of order of birth or of other factors associated with it is revealed in the proportion by which the actual deaths fall short of or exceed the expected deaths. The figures in table 16 show the

actual deaths in comparison with expected deaths when the influence of age of mother is eliminated.

The explanation of this calculation can be phrased in other terms. The series of ratios shows, in fact, the influence of order of birth (together with associated factors) when the effect of the disproportionate weight-

TABLE 16

Relative mortality by order of birth, when influence of age of mother is eliminated

Live births in eight cities

ORDER OF BIRTH	DEATHS			RATIO OF ORIGINAL RATE TO AVERAGE*
	Actual	Expected	Ratio of actual to expected*	
Total.....	2,555	2,555.3	100.0	100.0
First.....	652	704.1	92.7	94.2
Second.....	474	538.6	88.0	86.1
Third.....	348	356.8	97.6	94.1
Fourth.....	270	266.5	101.2	97.8
Fifth.....	210	192.7	109.0	106.8
Sixth.....	155	141.2	109.7	110.3
Seventh.....	126	106.2	118.4	123.0
Eighth.....	92	79.9	115.2	122.2
Ninth.....	69	57.3	120.2	132.0
Tenth and later.....	159	112.0	142.0	163.2

* Per cent.

ing of the various groups with births to younger or to older mothers is eliminated, or, more simply, when the influence of age of mother is eliminated from the relative rates.

The effect of eliminating the influence of age of mother appears slightly to diminish the excess mortality of first as compared with second births, and to lessen

the excess mortality of births of later as compared with births of earlier orders. The influence of order of birth, though diminished, is still marked.

Table 17 presents a similar computation showing the influence of order of birth after additional factors are eliminated, to wit, earnings of father and plurality of

TABLE 17
*Relative mortality by order of birth, when influences of age of mother
and earnings of father are eliminated*
Single live births in seven cities

ORDER OF BIRTH	DEATHS		
	Actual	Expected	Ratio of actual to expected*
Total.....	2,196	2,196.0	100.0
First.....	586	589.8	99.4
Second.....	410	454.3	90.2
Third.....	297	302.3	98.2
Fourth.....	232	232.9	99.6
Fifth.....	175	168.7	103.7
Sixth.....	119	124.0	96.0
Seventh.....	108	95.9	112.6
Eighth.....	75	71.6	104.7
Ninth.....	61	54.5	111.9
Tenth and later.....	133	101.8	130.6

* Per cent.

birth. The computations made in constructing this table are much more complicated than those made in constructing the preceding one, since each group of births classified by earnings of father, order of birth, and age of mother is multiplied by the average rate in the corresponding earnings-of-father and age-of-mother group; the results are then totaled to give the expected

deaths by order of birth. These expected deaths are the numbers that would be expected if full weight were given to the factors age of mother and earnings of father, but if no influence of order of birth were present. The differences between the actual and expected deaths show, as before, the influence of order of birth after the disturbing effects of these other factors have been eliminated.

It is of interest to note that the general trend of the rate by order of birth remains unaltered; the first births have a slightly higher rate than the second, and from the second there is a general tendency to increase with the later orders. The elimination of the two additional factors—earnings of father and plural birth—tends, however, to reduce still further the influence of order of birth as compared with that indicated by the original averages.

A second question concerns the influence of age of mother. Table 18 presents the relative ratios between the average rate and the rates for each age-of-mother group, first with no eliminations; second, when the influence of order of birth is eliminated; and, third, when the influences of order of birth, earnings of father, and plural birth are eliminated.

The effect of eliminating the influence of order of birth appears in the removal of the high mortality rate among the older mothers, which appears to be due largely to the influence of the high mortality rate attending births of late orders. The effect of eliminating the influence of earnings of father appears in lessening the excess mortality among the young mothers, a large proportion of whom are in families with low earnings.

Since the primary purpose of this chapter, as stated above, is to illustrate the application of Professor Westergaard's method of isolating the influence of the several factors, these examples may perhaps suffice. They are presented to show how the method can be applied to eliminate one, two, or more factors. As many factors should be eliminated as a thorough considera-

TABLE 18

Relative mortality by age of mother, when influence of certain other factors is eliminated

Live births in eight cities

AGE OF MOTHER	RATIO OF ACTUAL TO EXPECTED DEATHS*		
	On basis of average rate	Eliminating influence of order of birth	Eliminating influence of order of birth, earnings of father, and plural births
Total.....	100.0	100.0	100.0
Under 20.....	121.2	131.8	121.3
20-24.....	98.5	106.8	101.9
25-29.....	91.2	95.2	95.5
30-34.....	94.2	90.4	93.3
35-39.....	113.8	97.5	105.3
40 and over.....	122.9	92.4	91.1

* Per cent.

tion of the problem shows to be necessary. In many cases, however, the limitations in the amount or in the character of material available do not allow the exhaustive analysis that the nature of the problem requires.

One suggestion might be made as to an appropriate notation to express the operations and results of multiple classification and of the method of expected deaths.

Letting 1 denote the infant mortality rate, 2 order of birth, 3 age of mother, 4 earnings of father, 5 nationality of mother, 6 plural births, and similar subscripts for other factors, then table 15, for example, may be designated briefly B 2.3, or births classified by age of mother and order of birth. If subclassification by nationality of mother is introduced the table becomes B 2.3-5. Letting R denote the series of ratios of actual and expected deaths that shows the influence of a given factor such as order of birth upon the infant mortality rate, then the relation between the rate and order of birth may be stated simply $R_{1.2}$; if a factor such as age of mother is eliminated, it may be indicated by placing the corresponding number after a colon following the numbers indicating the relation shown, thus $R_{1.2.3}$. The third column of ratios in table 18, for example, may be designated, $R_{1.3:2-5-6}$.

Among the limitations of the method considered in this paper may be mentioned the following points: (1) The method requires a considerable amount of computation if more than one or two factors are eliminated; (2) the application of the method requires a mass of material commensurate with the number of factors to be eliminated, though no more than would be required by any other equally satisfactory method; (3) since it is an averaging process the method will yield satisfactory results only when an average is appropriate.

The last point may be illustrated by table 19, which shows infant mortality rates classified by age of mother and order of birth. Among births to young mothers the rate of infant mortality rises sharply from first to

third; while among births to mothers of the oldest groups shown the rate, high for first births, falls to a minimum for third births and rises to a very high figure for births tenth and later in order. These characteristic variations of the rate are obscured by an averaging process,⁸ unless such a process takes into account the interval between births which also enters as a factor in this case. Again, the averaging process indicated (table 18) that age of mother was not an unfavorable element in the rate of mortality among infants of older mothers; but the classified table of rates shows that for first births the infant mortality rate is higher among births to older mothers than to mothers between 25 and 29 years of age.

A further difficulty arising from this averaging process is the question of the effect of the weights chosen. The results, as can easily be shown, may vary considerably according to the weights. In this respect the

⁸ In mathematical terms, the partial derivative which measures the contribution of X_2 to X_1 when other factors are held constant may in general contain constant terms in X_3 , X_4 , and other factors. The condition that the partial derivative shall not vary with X_3 , X_4 , etc., requires an averaging process to find an expression for $\frac{\delta X_1}{\delta X_2}$ that contains no terms in any other variable. Such a process is appropriate only when the types and values of the partial derivative do not vary materially for different values of other variables.

If the additional condition is imposed that the partial derivative with respect to each factor be a constant, the expression becomes linear and corresponds to the familiar partial straight line regression equation $X_1 = b_{12.34} \dots X_2 + b_{13.24} \dots X_3$, etc.

It is clear that the application of the Westergaard method is somewhat broader than that of the partial straight line regression equation, and that the latter is equally inapplicable to cases in which an averaging process obscures the true significance of the variations in the rates.

method has the same advantages and the same weaknesses as the method of standardizing or correcting death rates, or of measuring price increases. Experience has indicated as a general rule to be followed that the weights chosen should agree as closely as possible with the "natural" weighting in the problem studied.

TABLE 19
Infant mortality rates, by age of mother and order of birth
Live births in eight cities

ORDER OF BIRTH	INFANT MORTALITY RATES*						
	Total	Age of mother					
		Under 20	20-24	25-29	30-34	35-39	40 and over
Total.....	111.2	135.7	109.3	101.4	104.7	126.5	136.7
First.....	104.7	125.5	100.5	90.4	102.8	131.6	
Second.....	95.7	167.2	105.6	74.0	76.8	112.7	
Third.....	104.6		125.0	103.8	82.1	73.1	
Fourth.....	108.8		155.3	99.7	106.6	82.1	
Fifth.....	118.8		97.7	136.2	96.7	127.5	
Sixth.....	122.7			150.4	102.1	128.8	
Seventh.....	136.8			195.7	121.8	131.3	108.9
Eighth.....	135.9				137.2	121.1	
Ninth.....	146.8				174.6	133.9	
Tenth and later.....	181.5				228.1	193.6	159.6

* Rates are not shown where base is less than 100.

Thus, if it is desired to eliminate the influence of age of mother, the actual weighting of the births by order of birth and age of mother yields the most satisfactory results and introduces no new element of arbitrary weighting into the problem. Care must always be exercised, however, in applying the method to determine whether the results are affected by the weights.

Errors of interpretation arising from these difficulties can always be avoided by a study of the rates classified by the several factors.

Among the advantages of the method are the following: (1) The results are stated in clear and simple terms; (2) the numbers upon which the results are based can be presented and the validity of the results judged thereby; (3) the method requires the constant use of the original material, which often suggests the necessity of taking into account factors, such as age of infant in connection with type of feeding, which might otherwise be overlooked; (4) it can be applied in certain cases even when the material cannot be classified so as to yield the full detail of rates;⁹ (5) it is not restricted to linear relationships but indicates any type of average relationship which may exist; (6) it is not restricted to factors which can be expressed numerically but can be applied equally well to factors, such as nationality and employment of mother, which are not susceptible of statement in numerical terms; and (7) it places in true relation the actual effect of each contributing factor after the influences of other factors have been eliminated.

⁹ For example, if the births can be fully, but the deaths or stillbirths only partially, classified. See Westergaard, *op. cit.*, Revised ed., pp. 333, 336; and "Scope and Method of Statistics," *loc. cit.*, p. 262.

CHAPTER V

BREAST AND ARTIFICIAL FEEDING¹

The superiority of breast over artificial feeding during the early months of infancy has long been recognized by the medical profession, and general principles in regard to the best modes of infant feeding have been developed. In view of the importance of the subject, however, statistical evidence of the relative influence of artificial and breast feeding upon infant mortality rates seems surprisingly meagre. Most of the data which are available relate to foreign cities or districts where special censuses of the kind of feeding received by the infant population have been taken and used in connection with records of the kind of feeding received by infants who died, or where other types of special inquiries have been made to ascertain the type of feeding prevailing.²

¹ Adapted by permission from *The Relation between Breast and Artificial Feeding and Infant Mortality*, published in *The American Journal of Hygiene*, Vol. II, No. 6, pp. 668-687, November, 1922.

² For example, Westergaard, H., in "Die Lehre von der Mortalität und der Morbilität," Revised Edition, 1901, p. 361, gives figures secured by Böckh for Berlin, based on a census of infants in the city and the returns as to type of feeding contained on death certificates. Dr. Groth and Professor Hahn made an extensive survey of the communes in Bavaria, in which the type of feeding was ascertained for samples of infants brought to vaccination stations (*Die Säuglingsverhältnisse in Bayern*, *Zeitsch. d. k. Bayerisch-Statistischen Landesamts*, 42d year, 1910, No. 1, pp. 78-164). For a statistical study of feeding in Boston, Mass., based upon a sample group of infants, see Davis, William H., M.D., *Statistical Comparison of the Mortality of Breast-fed and Bottle-fed Infants*, *Amer. Jour. Diseases of Children*, Vol. V, 1913, pp. 234-247.

In explanation of the relative lack of material on this subject, it should be mentioned that sound statistical treatment requires a comparison of the deaths of infants receiving each type of feeding with the time lived by infants while receiving the same type of feeding,—information which is not readily available.

The following analysis of the influence of feeding is based upon data for the 22,422 live born infants in eight cities studied by the Children's Bureau.³ These 22,422 infants are classified according to the feeding received during each month of the first year of life.⁴ The classification by months not only yields a statement of the total number of months lived by infants receiving each type of feeding, but also permits taking into account the change in the mortality rate by age and comparing for each month during the first year of life the relative mortality among infants receiving each type of feeding.

The kinds of feeding are classified into the three groups, exclusively breast, exclusively artificial, and partly breast and partly artificial feeding. This grouping is not wholly satisfactory. The groups of partial and exclusive artificial feeding are not classified in detail according to the character of the food given. Hence, the analysis of the effect of feeding on infant mortality

³ This number excludes from consideration 545 infants, or 2.4 per cent of the total number, who died not fed.

⁴ If the feeding changed during the month the infant was classified according to the type he received during the greater part of the month, since this rule gives the closest approximation to the months lived by infants receiving each type of feeding. In case of death during the month, the type of feeding received prior to death (except in cases where the feeding was changed by reason of sickness) was tabulated.

made in the present study is confined to the differences between exclusively breast feeding and exclusively artificial feeding, and between partial breast feeding and each of the other two groups, irrespective of the character of the artificial feeding.

Table 20 shows the increase in prevalence of artificial feeding from month to month during the first year of

TABLE 20
Type of feeding, by month of life
Infants in eight cities

MONTH OF LIFE	PER CENT OF INFANTS SURVIVING AT BEGINNING OF SPECIFIED MONTH OF LIFE		
	Exclusively breast-fed during the month	Partly breast-fed during the month	Exclusively artificially fed during the month
First.....	86.7	3.1	10.2
Second.....	78.3	5.9	15.8
Third.....	71.4	8.2	20.4
Fourth.....	62.7	12.4	24.9
Fifth.....	57.3	15.5	27.1
Sixth.....	51.7	19.3	29.0
Seventh.....	41.0	27.5	31.4
Eighth.....	35.1	31.9	33.0
Ninth.....	28.1	36.9	34.9
Tenth.....	20.5	41.5	37.9
Eleventh.....	15.9	44.0	40.0
Twelfth.....	13.3	44.6	42.0

life. In the first month 86.7 per cent of the infants were breast-fed, and 3.1 per cent were partly breast-fed, while 10.2 per cent were exclusively artificially fed. In the third month the proportion exclusively breast-fed had fallen to 71.4, while the proportion artificially fed had doubled, reaching 20.4 per cent. By the sixth month the proportion exclusively breast-fed was only

slightly over half, while that artificially fed had risen to nearly three tenths. By the ninth month less than three tenths, 28.1 per cent, were exclusively breast-fed, while the proportion partly breast-fed had increased to 36.9 per cent and that exclusively artificially fed had increased to 34.9 per cent. At the end of the first year of life, only 13.3 per cent of the infants continued to be entirely breast fed, but the proportion partly breast fed had risen to 44.6 per cent and that wholly artificially fed to 42.0 per cent. Up to the ninth month the proportion of artificially fed exceeded that of partly breast-fed infants. From the ninth to the twelfth this relative position was reversed, and the proportion partly breast-fed was slightly greater than that exclusively artificially fed. The greatest number of transfers from exclusive breast to partly breast or to artificial feeding took place between the sixth and the seventh months.

These figures can be summed up in convenient fashion in terms of months lived by infants who received each type of feeding. Taking for this purpose the figures for the first nine months only, since, as will be shown later, the type of feeding in these months is of greater importance than in the last three months of the first year of life, it is found that of the 192,212 months lived 57.4 per cent were lived by infants while breast-fed, 17.6 per cent while partly breast-fed, and 24.9 per cent while artificially fed. Thus not far from three fifths of the months lived up to and including the ninth month were months of breast feeding, and approximately one fourth were months of artificial feeding.

In table 21 monthly death rates are shown for each

month of life up to the twelfth. By comparing the rates for the three types of feeding in each month of life, the relation between mortality and type of feeding is made clear. In the first month the rate for artificially fed infants was over 3 times that for breast-fed infants; in the second month it was 4 times, in the

TABLE 21
Monthly mortality rates, by type of feeding
Infants in eight cities

MONTH OF LIFE	MONTHLY PROBABILITY OF DYING PER 1000 INFANTS			
	All types of feeding	Exclusively breast-fed	Partly breast-fed	Exclusively artificially fed
First.....	44.8*	16.9	36.4	54.7
Second.....	9.3	5.8	14.7	24.6
Third.....	8.1	3.7	12.9	21.2
Fourth.....	8.0	3.4	9.0	19.2
Fifth.....	7.7	3.3	5.7	18.1
Sixth.....	7.4	2.1	5.9	17.7
Seventh.....	6.3	1.9	4.0	14.1
Eighth.....	5.8	2.9	3.3	11.3
Ninth.....	5.7	3.2	2.9	10.7
Tenth.....	5.3	3.8	2.3	9.3
Eleventh.....	3.9	2.4	2.5	6.0
Twelfth.....	4.5	4.4	2.7	6.4

* The rate per 1000 fed is 21.5; 545 infants died not fed.

third nearly 6 times, in the fourth, fifth, sixth and seventh months over 5 times, in the eighth 4 times, and in the ninth slightly over 3 times the rates for breast-fed infants. After the ninth month the relative advantage of breast feeding was much less.

The relation between the rates for partly breast-fed infants and those for infants in the other two groups is

also shown. In each month up to the eighth the death rate for the partly breast-fed was higher than that for the wholly breast-fed, and lower than that for the artificially fed infants. In the first month the rate was twice that for exclusively breast-fed infants; it rose to nearly 3 times in the second month; in the third it was over 3 times, in the fourth nearly 3 times, in the fifth nearly twice, in the sixth nearly 3 times, in the seventh twice, in the eighth slightly greater, while in the ninth it was slightly less than the rate among wholly breast-fed infants. During the first nine months, the rate among partly breast-fed averaged about twice as high as that among wholly breast-fed infants. For the same period the death rate among the exclusively artificially fed averaged about 3 times as high as among the partly breast-fed babies.

A convenient method of summing up the relative disadvantage of artificial feeding shown in table 21 is to compare the deaths which actually occurred among the artificially fed infants with the number that would have occurred if the mortality rates among the breast-fed infants had prevailed among them. In this comparison, furthermore, allowance can be made for the decrease in the mortality rates by age. Applying the monthly death rates for breast-fed infants to the infants who were artificially fed in the corresponding months, it was found that instead of the 1,047 deaths that actually occurred among the artificially fed infants under one year of age only 268.7 deaths would have been expected at these rates of mortality. In other words the actual deaths were nearly four times the expected deaths.

Comparing in a similar way the number of deaths that actually occurred among all the partly breast-fed infants under one year with the number that would have occurred among them if the rates among the breast-fed had prevailed, it was found that only 203.9 deaths would have occurred instead of 269. The death rate among the partly breast-fed averaged slightly higher than among the breast-fed infants.

When the comparison was limited to the first nine months of life, however, the excess mortality both among artificially and among partly breast-fed infants appeared more marked. Thus during the first nine months 870 deaths of artificially fed infants occurred, as compared with only 181.1 that would have been expected at the rate of mortality prevailing among breast-fed infants. In other words, during this period the rates of mortality among the artificially fed averaged nearly five times as high as among the breast-fed infants. Among the partly breast-fed infants 201 deaths occurred during the first nine months, as compared with only 109.3 deaths expected on the basis of the rates prevailing among breast-fed babies. The monthly death rates among the partly breast-fed babies averaged, therefore, not quite twice as high as those among the more favored group of infants who received breast feeding.

The preceding discussion shows clearly that the statistical evidence favors breast feeding in the early months of life, and that in these months artificial feeding is fraught with excessive mortality. Two important questions concerning infant feeding are then raised. If an infant is exclusively breast-fed from birth at what

age should his breast feeding be supplemented by artificial food? And at what age should an infant be entirely weaned? Although the data do not answer these questions directly,—and of course general conclusions based upon statistics are not necessarily applicable to individual cases,—they furnish evidence on these points which is very suggestive.

Table 22 throws light upon the effect on mortality of a change from exclusively breast feeding to partially or exclusively artificial feeding at different times during the first year. Average monthly death rates from each month to the end of the first year of life are shown for two groups of infants who had been breast-fed up to the given month: those who continued to be breast-fed until the end of the year and those whose breast feeding ceased with or was first supplemented by artificial food during the given month.

The evidence indicates that, when the change occurred in the second, third, fourth, fifth, or sixth month, the average death rates for infants whose breast feeding ceased entirely or was first supplemented during those months were higher than those for infants who continued to be breast-fed. When the change was made in the seventh month or afterwards, however, the average death rates for infants whose feeding was changed were slightly lower than those for infants whose feeding remained unchanged.

An interesting point is that the monthly death rate for exclusively breast-fed infants reached its lowest point in the seventh month, and that both for the seventh and the eighth months the rates for this group were lower than the average monthly rates from the

TABLE 22

Relative advantage or disadvantage of a change from exclusively breast feeding, as shown by average monthly death rates from time of change to end of first year of life, by month of life in which change was made

Infants in eight cities

MONTH OF LIFE	INFANTS WHOSE BREAST-FEEDING CEASED OR WAS SUPPLEMENTED BEGINNING WITH SPECIFIED MONTH			INFANTS EXCLUSIVELY BREAST-FED	
	Months of lifetime until end of first year	Deaths	Average monthly death rate	Average monthly death rate from specified month to end of year	Monthly death rate in specified month
First.....	7,509*	92	12.3	4.5	16.9
Second.....	19,811	260	13.1	3.3	5.8
Third.....	14,915	155	10.4	3.1	3.7
Fourth.....	16,915	111	6.6	3.0	3.4
Fifth.....	9,480	44	4.6	3.0	3.3
Sixth.....	8,652	36	4.2	3.0	2.1
Seventh.....	13,722	36	2.6	3.1	1.9
Eighth.....	6,357	21	3.3	3.3	2.9
Ninth.....	5,848	14	2.4	3.4	3.2
Tenth and later.....	7,190	12	1.7	3.5	3.5

* The rate for the first month is not exactly comparable with those for later months. The figures for the second month, for example, include infants who were exclusively breast-fed in the first, but either partially or exclusively artificially fed in the second; the figure for the first month, however, includes only infants who were partially breast-fed during the greater part of the month, and these may or may not have received exclusively breast feeding for a period not exceeding two weeks. Infants who received exclusively breast feeding for less than 2 weeks and were then transferred to exclusively artificial feeding, on the other hand, are not included. These differences may explain the slightly lower rate found for the first month as compared with the second.

seventh or eighth months to the end of the year for either those who continued to be breast-fed or whose feeding was changed during the given months. A change in the ninth month, on the other hand, was associated with lower death rates than continued breast feeding.

As for the relation between the time of weaning and the average mortality rate, table 23 compares the average death rate from each month to the end of the first year of life for infants whose exclusively artificial feeding commenced in the given month with that for exclusively breast-fed infants.

The figures showed that weaning before the eighth month was associated, in the group of infants studied, with a relatively high mortality, as compared with that prevailing among breast-fed babies. When weaning was deferred until the eighth month, however, the mortality rates were not substantially higher than those for breast-fed infants, and in cases in which weaning was deferred until after the eighth month the rates appeared even slightly more favorable than those for babies who were exclusively breast-fed. Unfortunately, in the data available for study, the numbers of deaths of infants who were weaned during the later months of the first year of life were so small that comparatively little weight can be attached to the conclusions which the figures suggest.

A striking conclusion to which the data available in this study point is that the ill effects of early artificial feeding manifest themselves in increased mortality during the later months; in other words the health of artificially fed babies, as shown by the mortality rates,

appears to grow worse during the first few months following the commencement of early artificial feeding. This conclusion is suggested immediately by a compari-

TABLE 23

*Relative advantage or disadvantage of a change to exclusively artificial feeding, as shown by average monthly death rates from time of change to end of first year of life, by month of life in which change was made**

Infants in eight cities

MONTH OF LIFE	INFANTS WHOSE EXCLUSIVELY ARTIFICIAL FEEDING COM- MENCED IN SPECIFIED MONTH			EXCLUSIVELY BREAST-FED INFANTS	
	Months of lifetime up to end of year	Deaths	Average monthly death rate	Average monthly death rate up to end of year	Monthly death rate in specified month
First.....	23,189	535	23.1	4.5	16.9
Second.....	13,089	196	15.0	3.3	5.8
Third.....	10,015	128	12.8	3.1	3.7
Fourth.....	8,896	89	10.0	3.0	3.4
Fifth.....	4,149	34	8.2	3.0	3.3
Sixth.....	3,112	27	8.7	3.0	2.1
Seventh.....	3,425	17	5.0	3.1	1.9
Eighth.....	1,942	6	3.1	3.3	2.9
Ninth and later.....	5,059	16	3.2	3.4	3.4

* In table 23 infants exclusively artificially fed at some time during the first year of life are classified according to the month in which exclusively artificial feeding began; in table 22 infants exclusively breast fed at some time during the first year of life are classified according to the month in which breast feeding ceased or ceased to be exclusive.

son of the average death rates for artificially fed infants, for example, during the ninth to the twelfth months, 10.7, 9.3, 6.0, and 6.4 (table 21), with the aver-

age death rate, 3.4 (table 23), during the same months⁵ for infants whose artificial feeding commenced in these months. The comparison is between a group in which a large majority had had previous artificial feeding and a group in which all had enjoyed breast feeding up to the ninth month. Although, as will be shown later,⁶ the higher mortality in the former group was due in part to the fact that the group of infants whose artificial feeding commenced in the early months included a disproportionate number of babies who were physically weak, this comparison suggests that the length of previous artificial feeding played an important part in causing the high death rate.

Table 24 brings out this effect clearly by showing the monthly death rates for the various groups of babies classified according to the month in which their artificial feeding began. In each month of life the rate tended to be higher the longer the period of previous artificial feeding. In the fifth month, for example, the mortality rate was 24.0 for babies whose artificial feeding commenced in the first month, as compared with 18.7, 18.3, 13.6, and only 3.8 for babies whose artificial feeding commenced in the second, third, fourth, and fifth months, respectively.

The real significance of this tendency is brought out more clearly by comparison with the trend in the rates for breast fed babies. Infants whose artificial feeding began in the third month had a rate in that month which was 3.3 times, in the fourth month 4.7 times, in

⁵ From the time of commencing artificial feeding to the end of the first year of life.

⁶ See pages 91 and ff.

the fifth month 5.5 times, and in the sixth month 10.3 times the corresponding rates for breast-fed infants. This increasing disparity between the rates for arti-

TABLE 24

Monthly death rates, by duration of previous artificial feeding
Infants in eight cities

MONTH OF LIFE	DEATHS IN MONTH PER 1,000 INFANTS SURVIVING AT BEGINNING OF MONTH		DEATHS IN MONTH PER 1,000 INFANTS SURVIVING AT BEGINNING OF MONTH, WHO WERE ARTIFICIALLY FED FROM—									
	Exclusively breast-fed	Artificially fed	First month	Second month	Third month	Fourth month	Fifth month	Sixth month	Seventh month	Eighth month	Ninth and later	
First.....	16.9	55.2*	55.2									
Second.....	5.8	24.7	33.6	10.0								
Third.....	3.7	21.3	26.1	21.1	12.2							
Fourth.....	3.4	19.2	29.8	19.9	16.1	1.0						
Fifth.....	3.3	18.1	24.0	18.7	18.3	13.6	3.8					
Sixth.....	2.1	17.8	18.9	18.2	21.6	21.6	9.4	4.4				
Seventh.....	1.9	14.1	19.8	19.4	8.0	12.0	11.4	11.0	3.5			
Eighth.....	2.9	11.3	9.8	18.1	13.1	14.2	7.7	4.5	8.7	2.6		
Ninth.....	3.2	10.7	14.3	15.8	13.3	11.3	5.8	11.2	1.7	2.6		
Tenth.....	3.8	9.3	14.0	6.2	9.3	10.4	11.7	11.3	12.3	5.1	1.8	
Eleventh.....	2.4	6.3	6.8	10.8	8.4	3.2	7.9	6.9	3.5	5.2	3.9	
Twelfth.....	4.4	6.2	13.1	4.5	6.3	2.1	8.0	11.5	—	—	4.0	

* The slight differences which appear between these rates and those shown in table 21 are due to the omission in this table of a small number of cases in which exclusively artificial feeding was begun, but was later changed to partial or exclusively breast feeding.

ficially fed and for breast-fed infants, which appeared during the first few months after artificial feeding was begun, is convincing evidence that both the ill effects

of artificial and the good effects of breast feeding are cumulative.

From another point of view this cumulative effect can be traced in the trend of monthly death rates, shown in table 24, for the various groups of babies classified according to the month in which their artificial feeding began—following down the columns instead of across the rows. Thus the death rate for babies whose exclusively artificial feeding commenced in the third month was 12.2 in the third, 16.1 in the fourth, 18.3 in the fifth, and 21.6 in the sixth month. This tendency toward an increasing rate for babies who were artificially fed at an early age is in striking contrast to the general tendency for the death rate to decrease month by month during the first year of life.

An analysis of the death rates by cause of death (table 25) showed, as would be expected, that the excess mortality among infants who were artificially fed was greatest from gastric and intestinal diseases, the diseases especially connected with improper feeding. From the second to the ninth months the mortality from this cause among artificially fed infants was 11.3 times as great as among breast-fed infants, while in the tenth, eleventh, and twelfth months the excess mortality dropped rapidly until it was only 3.5 times as great. During the entire first year of life the mortality from this group of diseases among artificially fed infants averaged 7.7 times that among breast-fed infants. If the rates from gastric and intestinal diseases prevailing among breast-fed infants had prevailed among artificially fed infants, only 64 deaths would have been expected, as compared with the 495 which actually occurred, from these causes.

Not only were the rates from gastric and intestinal diseases markedly higher, but the rates from all the other principal causes appeared to be higher among artificially fed than among breast-fed infants. Among the artificially fed the death rate from respiratory diseases averaged 85 per cent higher than among the

TABLE 25

Excess mortality among artificially fed over that among breast-fed infants, by cause of death

Infants in eight cities

CAUSE OF DEATH	DEATHS AMONG ARTIFICIALLY FED INFANTS		
	Actual	Expected*	Ratio of actual to expected
Total.....	1,047	268.4	3.9
Gastric and intestinal diseases.....	495	64.2	7.7
Respiratory diseases.....	185	100.4	1.8
Malformations.....	26	5.9	4.4
Early infancy.....	165	27.1	6.1
Epidemic diseases.....	74	32.7	2.3
External causes.....	3	2.5	1.2
Diseases, ill defined or unknown.....	18	3.7	4.9
All other causes.....	81	31.9	2.5

* Expected, if the rates from each cause that prevailed among breast-fed infants had prevailed among the artificially fed infants.

breast-fed babies. The rates from malformations and from early infancy were four and six times as high respectively. The rate from epidemic diseases was over twice as high. The group of all other causes, including convulsions, meningitis, and congenital heart disease, had a mortality rate two and a half times as high, while the group of ill-defined causes had a rate

nearly 5 times as high among artificially fed as among breast-fed infants.

To a certain extent the higher rates from "all other causes" might be attributed to digestive disorders—in so far as they represented deaths ascribed to convulsions following upon gastric and intestinal diseases. Similarly the group of deaths from ill-defined causes might include many from these diseases. Even the group of causes peculiar to early infancy, especially in case of deaths ascribed to "congenital debility," might include many which were largely the result, and fairly to be ascribed to the effect, of improper feeding. For this term, according to the rules for classification in use by the Bureau of the Census, includes all deaths under one year which are assigned to such vague causes as debility, marasmus, emaciation, malassimilation, conditions which—in any case if they occur after the first or second month of life—are probably often due to improper feeding or to digestive disorders.

In this connection it may be noted that the mortality from congenital debility from the second to the twelfth months among artificially fed infants was 10.7 times that among breast-fed infants, a rate entirely comparable with the excess mortality from gastric and intestinal diseases. On the other hand, in the first month the excess mortality from this cause was only 3.1 times that among breast-fed infants.

Although part of the excess mortality from "congenital debility" appearing among the artificially fed is probably due to inaccurate return of the cause of death, nevertheless a considerable excess mortality from other causes peculiar to early infancy, including premature

birth, injuries at birth, and malformations, can be explained only on the hypothesis that there is a tendency for infants who are physically weak to be artificially fed in larger numbers than are normally endowed infants. The fact that such a tendency existed would not preclude the conclusion, of course, that the chances of life of these infants were greater if they were breast-fed than if they were artificially fed.

The foregoing analysis is based upon data for the entire group and the conclusions are stated without correction for possible correlated factors. It remains to determine whether the influence of correlated factors is such as to require a substantial modification of these conclusions: The principal correlations the influence of which must be considered in this connection are those between artificial feeding and (1) physical weakness, (2) nationality, and (3) economic status.

Was the excessive mortality among the artificially fed due to the inclusion in that group of a disproportionate number of infants belonging to groups which, possibly because of greater physical weakness, were characterized by extremely high rates,—such as twins and triplets, prematurely born babies, and infants whose mothers died within one year after confinement? In these three groups not only the rates from all causes, but also and particularly the rates from causes peculiar to early infancy, were unusually high;—those from all causes were 363, 541, and 450 per 1,000, respectively, as compared with an average rate of only 111, and those from causes peculiar to early infancy were 187, 405, and 257, respectively, as compared with an average rate for all infants of only 36. Whether

this excessive mortality indicates innate physical weakness of the infants, or shows the consequences of the physical condition of their mothers, or the results of unfavorable environmental conditions are questions which are not only difficult to answer satisfactorily but are immaterial to the present purpose; for the present purpose it is sufficient to show whether the mortality among artificially fed infants was increased by the inclusion among them of a disproportionate number of infants belonging to groups in which the mortality rates for other reasons than feeding were exceptionally high.

The evidence showed that in each of these groups infants were artificially fed in larger numbers than in the group as a whole. Thus, of the months lived up to the end of the ninth by twins and triplets 45.1 per cent were months of artificial feeding, as compared with only 24.5 per cent of the months lived by single infants. Similar percentages for premature infants and for infants whose mothers died were 43.8 and 82.8, as compared with 24.9 per cent for all infants.

Though the group of artificially fed infants is thus seen to have been overweighted by twins and triplets, by infants prematurely born, and by infants whose mothers died, each of these groups formed a very small proportion of the total. Thus, the twins and triplets were only 2 per cent of the total live births, the prematurely born infants 5 per cent, and the infants whose mothers died only 0.6 per cent. Of the months of artificial feeding up to the ninth 3.3 per cent were lived by twins and triplets, 6.5 per cent by infants prematurely born, and 1.4 per cent by infants whose

mothers died within one year after confinement, as compared with 1.1, 2.5, 0.1 per cent, of the months of breast feeding lived respectively by twins and triplets, by infants prematurely born, and by infants whose mothers died.

In the entire group of infants, as already noted, the mortality rates among the artificially fed averaged 3.9 times as high as among the breast-fed. Among the plural births alone the mortality of artificially fed infants averaged 3.6 times, while among the single births alone it averaged 3.8 times as high as among the breast-fed infants. Combining the results, instead of 1,047, only 279.2 deaths would have occurred in the entire group of artificially fed infants if the rates among single and plural breast-fed infants had been applied to the single and plural artificially fed infants respectively. The excess mortality thus averaged 3.75 times as high, even after the elimination of the influence of the excess weighting of the group of artificially fed infants by twins and triplets.

The effect of eliminating the influence of the other factors is, similarly, relatively slight. When the influence of the overweighting of the artificially fed group by infants who were prematurely born is eliminated, the excess mortality among the artificially fed is reduced only from 3.9 to 3.56. When the influence of the overweighting of the group of artificially fed by infants whose mothers died is eliminated, the excess mortality is reduced only from 3.9 to 3.69.

Since a much larger proportion of plural than of single births were prematurely born, the reduction in the relative excess mortality due to eliminating

the influence of prematurity might in part duplicate the reduction due to eliminating the influence of plural birth. Nevertheless, when both these factors were eliminated, the reduction in the relative excess mortality was only from 3.9 to 3.4. When all three factors were eliminated the mortality among artificially fed infants still averaged 3.3 times that among breast-fed infants.

This analysis, though somewhat technical, shows clearly that the effect of the overweighting of the group of artificially fed infants by infants in groups having high mortality rates was of minor importance in comparison with the marked excess mortality associated directly with the kind of feeding.

Reference has already been made to the possible influence which the tendency to feed artificially infants in certain groups characterized by high mortality rates in larger proportions, or beginning at earlier times, than other infants might have in increasing the apparently cumulative effect of the type of feeding. Of the infants who were artificially fed beginning in the first month, 12.4 per cent were either prematurely born or were twins or triplets, as compared with an average of 7.3 per cent of those beginning artificial feeding in the second and third months, an average of 5.0 per cent of those beginning in the fourth to seventh months, and an average of only 3.8 per cent of those beginning in the eighth to twelfth months.

To eliminate the effect of such an influence, table 26 exhibits the monthly death rates among artificially fed single infants who were born at term and whose mothers lived throughout the year following their

births, classified according to the month when artificial feeding commenced. The effect of eliminating the three groups previously discussed was to reduce materi-

TABLE 26

Monthly death rates, by duration of previous artificial feeding, omitting prematurely born infants, twins and triplets, and infants whose mothers died within the year following confinement

Infants in eight cities

MONTH OF LIFE	DEATHS IN MONTH PER 1,000 INFANTS* SURVIVING AT BEGINNING OF MONTH		DEATHS IN MONTH PER 1,000 INFANTS* SURVIVING AT BEGINNING OF MONTH, WHO WERE ARTIFICIALLY FED FROM—								
	Exclusively breast-fed	Exclusively artificially fed	First month	Second month	Third month	Fourth month	Fifth month	Sixth month	Seventh month	Eighth month	Ninth and later months
First.....	11.7	32.2	32.2								
Second.....	4.9	20.3	27.4	9.3							
Third.....	3.4	17.9	18.2	21.3	13.3						
Fourth.....	3.1	17.6	28.1	17.4	15.6	1.0					
Fifth.....	2.9	17.0	21.4	20.3	17.9	12.3	2.0				
Sixth.....	1.9	17.2	18.3	18.1	21.5	19.7	9.9	4.7			
Seventh.....	1.8	12.7	15.6	19.3	8.8	10.6	12.0	9.4	3.7		
Eighth.....	3.0	8.6	9.8	11.2	7.7	10.7	6.1	4.7	7.4	2.7	
Ninth.....	3.2	9.8	12.3	13.3	13.4	11.9	6.1	11.9	—	2.7	
Tenth.....	3.4	8.8	12.5	4.8	10.2	10.9	10.2	9.6	13.0	5.3	1.9
Eleventh.....	2.5	6.4	6.3	11.6	8.0	3.3	8.3	7.3	3.8	5.4	4.0
Twelfth.....	4.5	5.7	11.5	3.9	6.9	2.2	6.3	12.3	—	—	4.2

* Omitting prematurely born infants, twins and triplets, and infants whose mothers died within year following confinement.

ally the excess mortality among infants who were artificially fed from the first month, as compared with that among infants whose artificial feeding commenced

later. This elimination, however, did not alter the general conclusion previously reached. In the fifth month, for example, the rate of infant mortality was higher the longer the period of previous artificial feeding. The tendency already noted for the rate to increase, relatively to the rate among breast-fed infants, immediately following the beginning of artificial feeding at an early age was still found to hold true for this group of infants. Among the infants whose exclusive artificial feeding commenced in the second month, for example, a mortality rate prevailed in that month which was 1.9 times the rate among breast-fed infants; the rate in the third month, however, was 6.3 times, in the fourth month 5.6 times, and in the fifth month 6.9 times the corresponding rates among breast-fed infants. Among the infants whose exclusive artificial feeding commenced in the third month, a rate prevailed in that month which was 3.9 times, in the fourth month 5.0 times, and in the fifth month 6.1 times the corresponding rates among breast-fed infants. In fact, the elimination of the group of premature and plural births and of infants whose mothers died within one year after the births appears not to weaken, but even to strengthen, the evidence that the type of feeding had a cumulative effect during the early months of life.

Two other questions remain for consideration. Was the excess mortality among artificially fed infants due in any part to a tendency for infants in the low income groups, or for infants of nationalities for which the mortality rates were high, to be artificially fed in larger proportions than those in groups for which the mortal-

ity rates were low? In other words, was the excess mortality, already shown to have existed among infants artificially fed, due to a difference that depended upon the type of feeding, or was it merely a reflection of differences in mortality connected with other causes, such as race or income?

TABLE 27

Prevalence of artificial feeding, by nationality of mother
Infants in eight cities

COLOR AND NATIONALITY OF MOTHER	PER CENT OF ARTIFICIAL FEEDING*
All mothers.....	24.9
White.....	25.2
Native.....	28.3
Foreign.....	21.2
Italian.....	13.1
Jewish.....	11.3
French-Canadian.....	44.0
German.....	21.5
Polish.....	11.1
Portuguese.....	31.9
Other.....	23.2
Colored.....	19.7

* Per cent based on total months lived during first nine months of the first year of life.

The differences in the prevalence of artificial feeding in the several race and nationality groups are exhibited in table 27. The French-Canadian group had the largest proportion of artificially fed infants, and the Polish and Jewish had the lowest proportions. The nationalities with mortality rates above the average included the French-Canadian, the Polish, the Portu-

guese and the colored; of these two had high and two had low proportions artificially fed. Evidently the differences between the several groups tended at least in part to offset one another. When allowance was made, therefore, for differences in the prevalence of artificial feeding in the several nationality groups, the excess mortality ratio among the artificially fed as compared with the breast-fed infants was slightly, but only very slightly, increased, from 3.9 to 4.0. Hence, the correction for nationality did not appreciably affect the result.

The relative ratio between the average mortality among artificially fed and that among breast-fed infants varied considerably from group to group, as shown in table 28. The excess mortality among artificially fed was only 2.2 times that among breast-fed in the Italian group, one in which both rates were relatively low; while among the native white the ratio rose to 5.3 and among the German to 5.6.

So far as earnings of fathers were concerned, artificial feeding appeared to be more prevalent in the groups with high earnings, which had comparatively low infant mortality rates. Thus, of the months up to the end of the ninth lived by infants whose fathers earned under \$550, 21.8 per cent were months of artificial feeding, as compared with 30.0 per cent of the months lived by infants whose fathers earned \$1,250 and over.

When allowance was made for this greater tendency toward artificial feeding in the higher income groups, the relative excess mortality among artificially fed as compared with breast-fed infants was slightly increased. As stated above (p. 81) for the first nine months of

life this relative excess was 4.8 times; but when the data for one city for which earnings were not exactly comparable with the others were omitted, this relative excess was slightly altered to 5.1 times. Making the allowances for the negative correlation between arti-

TABLE 28

Relative excess mortality among partly breast-fed and exclusively artificially fed, as compared with breast-fed infants, by color and nationality of mother

Infants in eight cities

COLOR AND NATIONALITY OF MOTHER	DEATHS AMONG INFANTS					
	Partly breast-fed			Exclusively artificially fed		
	Ex-pected	Actual	Ratio	Ex-pected	Actual	Ratio
All mothers.....	207.7	269	1.3	261.2	1,047	4.0
White.....	172.4	240	1.4	234.6	963	4.1
Native.....	53.3	91	1.7	94.1	503	5.3
Foreign.....	119.1	149	1.3	140.5	460	3.3
Italian.....	19.8	17	0.9	13.7	30	2.2
Jewish.....	12.8	6	0.5	5.5	16	2.9
French-Canadian.....	10.4	19	1.8	39.4	95	2.4
German.....	6.4	8	1.3	6.2	35	5.6
Polish.....	24.4	39	1.6	12.3	60	4.9
Portuguese.....	10.1	24	2.4	17.0	73	4.3
Other.....	35.2	36	1.0	46.4	151	3.3
Colored.....	35.3	29	0.8	26.6	84	3.2

ficial feeding and earnings the excess mortality ratio was raised from 5.1 to 5.3. The correction resulting from this correlation is thus seen to be relatively slight.

The relative excess mortality ratio of artificially fed infants in each of the principal earnings groups is shown in table 29. The ratio was much higher,

6.3, in the group with earnings "Under \$550" than in the group with earnings of \$1,250 and over, where it was only 4.1. It might well be that this difference in the ratio corresponded to differences in the type of artificial feeding or to differences in the care with which feeding was given in the various earnings groups.

TABLE 29

Relative excess mortality during first nine months among artificially fed as compared with breast-fed infants, by earnings of father

Infants in seven cities

EARNINGS OF FATHER	DEATHS AMONG ARTIFICIALLY FED INFANTS DURING FIRST NINE MONTHS*		
	Expected†	Actual	Ratio‡
Total.....	147.0	778	5.3
Under \$550.....	50.4	315	6.3
\$550-\$849.....	62.3	313	5.1
\$850-\$1,249.....	26.5	118	4.5
\$1,250 and over.....	7.8	32	4.1

* Excluding infants in no earnings and earnings not reported groups.

† Expected, if the rates for breast-fed infants in each earnings group had prevailed among the artificially fed infants in the same group.

‡ Ratio of actual to expected deaths.

In conclusion, the analysis showed that artificial feeding, as actually practiced in typical city populations, was associated with a mortality between three and four times as high as the mortality among breast-fed infants. This excess mortality was not to be explained by the slight overweighting of the group of artificially fed with infants in certain groups charac-

terized by high mortality rates; and it appeared in all nationality and in all earnings groups, though with variations depending probably upon the particular conditions prevailing in the groups.

It would be of especial interest to follow through these variations by nationality and earnings to discover, if possible, the causes of these differences. And it would be of great importance to demonstrate statistically the influence upon mortality of the different types of artificial feeding, and whether in case of each of these types there appeared the cumulative effect that characterized the group of artificially fed infants in the present study.

CHAPTER VI

RACE AND NATIONALITY

The fact is well known that infant mortality rates differ markedly from race to race and from nationality to nationality. A comparison of rates in various countries shows great differences; for example, the rate for New Zealand in 1922 was only 42 while that for Chile was 240. Table 30 gives a summary statement of the rates in the principal countries of the world for the year 1922, the latest year for which all the rates are available.

The explanation of these variations is often difficult to discover. Differences between the rates for New Zealand and for Great Britain and Ireland—the nationalities being substantially the same—can be explained in part by the extraordinarily favorable climatic conditions in New Zealand, and in part by the special measures adopted in that country for the protection of infant life. But the question should also be raised for consideration whether in the settlement of New Zealand selection of the more hardy and vigorous stocks might not have played a part in producing the remarkably low mortality in the newer land.

Certain questions of climate and other external environmental conditions can be eliminated by considering infants of different racial origins born in the same country. In the United States, in which many nationalities are represented, data are available to show the infant mortality rates of these nationalities in

substantially the same environment, at least so far as climatic conditions are concerned. These rates are

TABLE 30

Infant mortality rates in the United States and certain foreign countries, 1922

COUNTRY AND YEAR	INFANT MORTALITY RATES*
Australia.....	52.7
Austria.....	153.9
Belgium.....	113.8
Chile.....	240.2
Denmark.....	68.8
England and Wales.....	77.1
Finland.....	99.2
Germany.....	129.7
Hungary.....	199.8
Irish Free State.....	68.9
Japan.....	166.4
The Netherlands.....	77.3
New Zealand.....	41.9
Norway.....	54.9
Scotland.....	101.4
Spain.....	145.2
Sweden.....	63.1
Switzerland.....	69.6
Union of South Africa.....	72.9
United States Birth Registration Area.....	76.2
Uruguay.....	93.5

* Deaths under one year per 1,000 live births. The figures as usually quoted for Belgium and the Netherlands exclude from both births and deaths a small number of deaths before registration of live born infants: the figures given above have been corrected so as to be comparable with the rates for other countries. The data, which were compiled from official sources, were furnished by courtesy of the United States Children's Bureau.

shown in table 31. In general, the several countries of origin maintain approximately the same relative position as in table 30.

The fact that the different nationalities show the same tendencies in this country as in their native lands so far as infant mortality is concerned may be due to the permanence of national customs and traditions affecting important features of the infant's environ-

TABLE 31

*Infant mortality rates, by race, and by country of birth of mother, United States birth registration area, 1922**

RACE, AND COUNTRY OF BIRTH OF MOTHER	INFANT MORTALITY RATES
Total.....	76.2
White.....	73.2
United States.....	68.0
Foreign.....	85.2
Austria, Hungary.....	94.0
Canada.....	86.4
Denmark, Norway, Sweden.....	59.2
England, Scotland, Wales.....	66.0
Ireland.....	83.0
Germany.....	72.9
Italy.....	81.7
Poland.....	105.9
Russia.....	59.6
Other foreign countries.....	100.5
Negro.....	111.7
Other colored.....	89.9

* Source: Birth, Stillbirth, and Infant Mortality Statistics for the Birth Registration Area of the United States, 1922. Eighth Annual Report, p. 52.

ment, such as type of feeding, kind of care, employment of physician or midwife at confinement, employment of mother before childbirth,—customs which may be transferred bodily to the new country and produce here the same results that they produced in the

native land. In short, this comparison merely raises more questions than it can answer. Nevertheless, it does suffice, perhaps, to reveal the limits of the influence which climate or factors associated with climate exercise over infant mortality.

In general, two types of explanation are advanced for differences in rates between different races and nationalities. One seeks the principal causes in innate or inherited characteristics; the other seeks them in acquired characteristics—customs and traditions—and in environing circumstances. Both explanations, of course, may be true in part, and, if so, the question is to what extent each is valid. The only method of answering this question is to eliminate the influence of one factor after another until as many factors as possible have been eliminated; and to study the final result in the light of these eliminations. In practice, it is easier to eliminate the influence of environmental factors, since they can be more easily measured and expressed in quantitative terms; to measure the effects of inborn qualities or characteristics is difficult because of doubt as to whether any particular quality is or is not an innate racial or national trait. On the other hand, a quality or characteristic the influence of which is obviously environmental may itself be affected by innate characteristics.

Two examples may make these points clearer. It is sometimes alleged that the proportion of deaths in early infancy shows innate racial tendencies. But an analysis of these deaths shows that the rates vary with the economic position of the families, with the care which the mother received during pregnancy,

with whether or not the mother worked during the months immediately preceding childbirth, and with other factors which are obviously environmental. In studying the proportion of infant deaths or of premature births, therefore, care must be taken to eliminate the influence of environmental factors before drawing any definite conclusion as to the precise importance which is to be attached to innate racial characteristics. As an example of the other sort, the influence of type of feeding, whether breast or artificial, is obviously environmental. But, though this factor is itself environmental, the prevalence of breast feeding may be affected markedly by innate racial or national qualities. This question is, indeed, a moot point, some authorities holding that differences in the proportions of breast-fed infants are due largely to differences in the capacity to breast-feed, and others holding that these differences are not fundamentally racial or inherited but are primarily due to customs and traditions, or to knowledge or ignorance of the hygiene of breast feeding.

The questions raised as between these two types of explanation of the significance of variations in infant mortality rates by nationality are well nigh unanswerable. Nevertheless, in view of the unusual possibilities for analysis afforded by the detailed data secured by the Children's Bureau, it will be of interest to trace the effect of eliminating the influences of the various complicating factors in order to ascertain what new light such elimination may throw upon these questions.

The data afforded in these studies permit the elimination, for example, of economic status as typified by the father's earnings, of type of feeding, of differences

in prematurity and in plural births, and of the factors associated with variations in the birth rate. What is the effect of these eliminations? Do they materially alter the relative rank of the nationalities in their infant mortality rates? What influences associated with nationality are left after these factors are eliminated? What final conclusion, if any, can be drawn as to the relative effect of environmental and of hereditary factors in causing the differences in rates for the different nationalities?

For the study of the influence of race and nationality each infant in the eight cities was classified according to the mother's race—whether white or colored—and nativity—whether native or foreign born—and each one whose mother was foreign born was classified according to the mother's nationality (mother tongue). The nationality of the mother, instead of that of the father, was selected for tabulation not only because an infant's vitality depends in large part upon the mother's health and condition during pregnancy but also because the care received depends upon the mother's condition and to some extent upon the customs and traditions of the nationality to which the mother belongs. In particular, the type of feeding is influenced by the national traditions and customs as to maternal nursing. Though the customs and traditions of the father's nationality, in the comparatively few cases in which it differed from that of the mother,¹ might also have influenced the child's welfare, the influence of such factors was exerted

¹ In one city for which a special tabulation of this point was made, 1,911 infants out of 2,197 (87 per cent) had fathers and mothers of the same race and nationality group.

principally through the relation, if any, which nationality bore to earnings. So far as the influence of innate inherited racial characteristics is concerned the fact that nearly nine-tenths of the fathers were of the same race and nationality as the mothers seems to indicate that the classification on the basis of the race and nationality of the mothers would take into account the influence of these innate racial characteristics.

To what extent were the differences in the rates according to nationality due to differences in type of feeding, earnings of father or other environmental factors, and to what extent were they traceable to hereditary or innate racial characteristics?

The total effects of all the factors associated with nationality are shown, in table 32, in the infant mortality rates from the principal causes of death. The rates from all causes showed marked variations; the rate for colored was decidedly higher than that for white infants, 154.4 as compared with 108.3. Infants of foreign-born mothers had a considerably higher rate (127.0) than white babies whose mothers were born in this country (93.8). Among the foreign nationalities wide differences were found. The lowest rate was 53.5 for infants of Jewish mothers—a markedly lower mortality than that in the native white group. The highest rate (200.3) was found for babies whose mothers were Portuguese. The infants of German and Italian mothers had relatively low rates—103.1 and 103.8, respectively; and those of Polish and French-Canadian mothers had relatively high rates—157.2 and 171.3, respectively.

With one or two exceptions the nationalities held

about the same relative positions in mortality from each of the principal causes of death as they held in mortality from all causes. The infants of Jewish mothers, for example, who had the lowest rate from all causes, had by far the lowest mortality both from gastric and intestinal and from respiratory diseases and next to the low-

TABLE 32

Infant mortality rates, by cause of death and color and nationality of mother

Live births in eight cities

COLOR AND NATIONALITY OF MOTHER	INFANT MORTALITY RATES FROM SPECIFIED CAUSES					
	All causes	Gastric and intestinal diseases	Respiratory diseases	Early infancy	Epidemic diseases	Other causes
Total.....	111.2	32.4	19.6	36.1	7.1	16.1
White.....	108.3	32.6	17.9	35.1	6.4	16.4
Native.....	93.8	25.2	13.0	36.1	5.4	14.1
Foreign born.....	127.0	42.2	24.2	33.7	7.7	19.2
Italian.....	103.8	21.7	27.3	33.7	7.7	13.3
Jewish.....	53.5	10.5	8.9	22.7	4.9	6.5
French-Canadian.....	171.3	64.2	25.1	44.7	6.5	30.7
German.....	103.1	27.1	18.0	30.9	11.6	15.5
Polish.....	157.2	64.0	33.2	38.7	3.9	17.4
Portuguese.....	200.3	101.6	50.8	20.9	14.9	12.0
Other.....	129.6	38.5	20.6	35.8	8.1	26.7
Colored.....	154.4	28.1	44.6	52.2	17.2	12.4

est from epidemic diseases and from causes peculiar to early infancy. In the native white group, which had next to the lowest rate from all causes, the mortality was distinctly below the average from gastric and intestinal, from respiratory, and from epidemic diseases, and equal to the average from causes peculiar

to early infancy. The babies of German mothers had rates below average except from epidemic diseases. In the Italian group the mortality was below average except from epidemic and from respiratory diseases; from gastric and intestinal diseases it was next to the lowest. The infants of Polish and French-Canadian mothers had death rates from gastric and intestinal diseases that were twice as high, and those of Portuguese mothers a rate from these causes that was over three times as high, as the average. In these three groups the mortality from respiratory diseases was markedly above the average; their rates from other causes were also high, except that the Portuguese had the lowest mortality of all from causes peculiar to early infancy and the Polish the lowest of all from epidemic diseases.

In general, these findings call for no especial comment although it should be pointed out that the specific rates from the individual causes are really of more importance than the rates from all causes when it is a question of tracing the influence of environmental and hereditary factors in mortality. For example, the influence of type of feeding, as developed in the preceding chapter, would be perhaps most strongly indicated in the mortality from gastric and intestinal diseases, while the influence of the employment of the mother during pregnancy might have its greatest influence over the death rate from causes peculiar to early infancy. Nevertheless, if the rate from all causes is high it is natural to expect that the rates from the individual causes which together make up the total will also be high. And in general the rate from all causes

in each nationality runs so closely parallel with the rates from the various specific causes that, in making allowances for the various factors correlated with nationality, the analysis can be simplified by considering primarily only the general rates.

The special cases, however, which show departures from this tendency deserve most attention; of these perhaps the most interesting is the exceptionally low rate from causes peculiar to early infancy which was found for the Portuguese group. This curious exception to the general tendency for the rate from all causes to run parallel with the rates from the specific causes finds a partial explanation when a study is made of the figures for neonatal mortality. Variations in the neonatal mortality rates—or deaths during the first month of life—run parallel with variations in the rates from causes peculiar to early infancy in each nationality group with again a single exception, the Portuguese. Though the Portuguese had the lowest rate of all from diseases peculiar to early infancy, their mortality during the first month of life was only slightly below the average. In other words, the variations in the neonatal mortality rates corresponded more closely than did those in the mortality from early infancy with the variations in the mortality from all causes.

Study of the deaths that occurred during the first month among the Portuguese infants indicated, however, that a large proportion of them were charged to gastric and intestinal diseases; whereas among other deaths during the first month practically all were charged to causes peculiar to early infancy. In general, reports of deaths from gastric and intestinal diseases

during the first week or two of life are not to be credited. This marked difference suggests, therefore, that the diagnoses of causes were not equally satisfactory in the several nationality groups. On the other hand, the peculiar customs of early infant feeding found among the Portuguese, who frequently gave "sopa," a soup containing softened crackers, to babies a few hours old, might perhaps account for the occurrence in this group of a particularly large number of deaths from gastric and intestinal diseases at ages under one month.

The correlations between nationality and the rates for the several causes of death which have just been discussed relate to the total influences associated with nationality irrespective of whether they are due to conditions resulting from heredity or from environment. The question should next be considered, to what extent is the total result explained by correlations with type of feeding, economic status, factors associated with the birth rate, or other specific factors? And, finally, when allowances have been made for these influences, what influence is left to be considered as associated with nationality?

The two most important of the environmental influences are type of feeding and economic status; these will be considered first.

With respect to type of feeding marked differences were found between the customs of the different nationality groups. Of the months lived by the different groups of babies from birth up to the end of the ninth, those whose mothers were Italian had the largest proportion, 68.6 per cent, during which they were exclusively breast-fed, followed closely by those

of Polish mothers with 63.9 per cent, and by those of Jewish mothers with 61.5 per cent. The lowest proportion, 42.7 per cent, of months of breast feeding, was found for the French-Canadian group.

The greatest prevalence of artificial feeding, on the other hand, was found in the French-Canadian group; the infants of French speaking mothers from Canada were fed artificially during 44.0 per cent of the months which they lived from birth to the end of the ninth. The Portuguese group came next with 31.9 per cent, followed by the native white with 28.3 per cent. The lowest proportions were for the infants of Jewish and of Polish mothers, 11.3 and 11.0 per cent respectively.

Since the practice of artificial feeding was fraught with greatly increased hazards to the infants, these differences in the prevalence of breast and of artificial feeding in the several nationality groups were important in explaining differences between their mortality rates.

With one or two exceptions, variations in the prevalence of artificial feeding corresponded to variations in the infant death rates. Thus, the Jewish group, which had an unusually low proportion of infants artificially fed, had the lowest mortality, while the Portuguese group, in which a very large proportion of infants were artificially fed, had the highest mortality. As a noteworthy exception should be mentioned the practically equal prevalence of artificial feeding among the Jewish and the Polish infants, accompanied in the case of the Jewish group by a very low, but in the case of the Polish group by a very high, death rate. The mortality from gastric and intestinal diseases among

Polish infants was six times as high as that among Jewish. Evidently, the influence of similarity in prevalence of the several types of feeding must have been less powerful in these two groups than other factors—differences perhaps in the quality of the artificial

TABLE 33

Relative mortality by nationality of mother, when influences of type of feeding and earnings of father are eliminated

COLOR AND NATIONALITY OF MOTHER	RATIO OF ACTUAL TO EXPECTED DEATHS*			
	On basis of average rate	Eliminating influence of type of feeding	Eliminating influence of earnings of father	Eliminating influences of type of feeding and earnings of father
Total.....	100.0	100.0	100.0	100.0
White.....	97.4	96.9	99.2	98.3
Native.....	84.4	80.9	95.3	88.5
Foreign-born.....	114.2	119.4	103.4	109.3
Italian.....	93.4	109.9	76.6	86.8
Jewish.....	48.1	55.6	48.1	49.3
French-Canadian.....	154.0	127.9	154.9	127.6
German.....	92.7	94.2	92.7	97.0
Polish.....	141.4	169.5	118.1	149.5
Portuguese.....	180.1	166.5	146.9	141.1
All other.....	116.5	119.9	106.2	106.5
Colored.....	138.8	149.3	108.4	118.4

* Per cent.

food, perhaps in social and economic environment, perhaps in physical vitality.

How would the nationalities have ranked if there had been no differences in prevalence of the different types of feeding? This question is answered by the figures in the second column of table 33, which gives

the ratio of actual to expected deaths when the influence of type of feeding has been eliminated. After making this allowance the Jewish group maintained the same position of leadership as before. The infants of native white mothers had the next most favorable rate; in this case, though the giving of artificial food was more prevalent than in any group except the French-Canadian and the Portuguese, the mortality among both the breast-fed and the artificially fed was low as compared with that among the breast-fed and the artificially fed infants of most of the other nationalities. The German group ranked more favorably than the Italian, though their rates were practically identical when no allowance was made for differences in feeding; in other words, in the Italian group a less favorable mortality experience associated with other factors was offset by a greater prevalence of breast feeding. The relative rank of Polish, French-Canadian, and Portuguese infants was altered; the mortality in the French-Canadian group was changed to the lowest position, while that in the other two groups was left approximately the same, but with the Polish slightly higher. The markedly greater prevalence of breast feeding among the infants of Polish mothers tended to offset an otherwise relatively very unfavorable mortality experience, and, therefore, before allowance was made for variations in the prevalence of breast and artificial feeding the rate for this group appeared lower than that for the French-Canadian or Portuguese infants.

It is clear that, though differences in prevalence of breast and artificial feeding produced a decided influence over the rates for the several nationality groups,

marked differences in mortality still remained to be accounted for by other factors.

The second important cause of differences in environmental influences affecting the infant death rates of the various nationalities was economic status. Table 34 shows striking variations between the nationality and race groups in the proportions of families in each

TABLE 34

Per cent of births in families in which the father earned less than \$650

COLOR AND NATIONALITY OF MOTHER	PER CENT OF LIVE BIRTHS IN FAMILIES IN WHICH THE FATHER EARNED LESS THAN \$650
Total.....	42.4
White.....	39.6
Native.....	27.4
Foreign-born.....	55.3
Italian.....	70.5
Jewish.....	44.5
French-Canadian.....	43.2
German.....	41.2
Polish.....	78.3
Portuguese.....	78.5
Other.....	45.0
Colored.....	81.9

of which the father earned less than \$650 during the year following the birth of the infant. This proportion was highest for the colored group, in which 81.0 per cent of the births occurred in families the fathers of which earned less than \$650 each; it was lowest, 27.4 per cent, in the native white group. Marked differences appeared between the various foreign nationalities

ties. Of these the German group had the lowest proportion, 41.2 per cent, of births in families the fathers of which earned less than \$650, followed closely by the French-Canadian with 43.2 per cent and the Jewish with 44.5 per cent; the Italians, the Polish, and the Portuguese all had high proportions, 70.5, 78.3, and 78.5 per cent, respectively, of births to such economically low-status fathers.

A comparison of these percentages with the infant death rates given above shows that the differences in economic status, as measured by father's earnings, run parallel with and correspond closely to differences in mortality.

What would the rates in the several nationality groups have been had there been no differences between them in economic level? This question is answered in the third column of table 33 which shows the relative rank of the nationalities in infant mortality rates on the assumption that no differences existed in the proportions of families in the several father's earnings groups. Several striking changes in relative position were found. The mortality among the colored infants, for example, no longer appeared so high as before; the high rate shown in the unadjusted figures seemed to have been largely a reflection of low economic status. Among the Polish, too, low earnings of fathers appeared to have accounted for a large part of the excessive infant death rate. The mortality among the children of Italian mothers likewise appeared much more favorable when allowance was made for the effect of their relatively low economic position; while the favorable experience of the infants of native white mothers

seemed to have been due, in part at least, to the comparatively superior economic status of their fathers. In the French-Canadian group, on the other hand, a mortality considerably above the average appeared not to be accounted for by any differences in father's earnings. And under this method of comparison the mortality among the Jewish infants still appeared lowest of all.

The question as to what the relative rates in the different nationalities would have been if there had been no differences either in type of feeding or in economic status is answered by the figures in the last column of table 33. In two or three cases these two factors seemed to have offset each other. The mortality among the infants of Italian mothers, which was slightly below the average for the entire group, was influenced by two marked causes, exactly opposite in their effects,—an unusual prevalence of breast feeding and an unusually low economic status. When allowance was made for the former only, the rate appeared to be excessive because of the influence of low economic status; when allowance was made for the latter only, the rate appeared to be unusually favorable because of the influence of the favorable feeding. But when allowance was made for both factors together, as in the last column of table 33, the relative position of the Italian babies appeared only a trifle more favorable than than indicated in the original figures.

Perhaps the effect of these eliminations may be summed up by saying that they appear to lessen the variations associated with nationality; the high rates especially appear to have been due to combinations of

unfavorable feeding and unfavorable economic status. But it is noteworthy that the mortality among the infants of Jewish mothers still maintained its remarkably low relative position even after both these factors had been eliminated.

Other eliminations were found to be of comparatively little importance. The factors which are associated with the birth rate,—age of mother, order of birth, interval since preceding birth, and interval before succeeding pregnancy,—tended in part to offset one another and did not show in fact very great differences between nationalities. So far as age of mother was concerned, comparatively slight differences were found in the percentages of births to mothers of ages for which the infant mortality rates were above average,—namely, births to mothers under 20 and to those over 35 years of age. The proportion was highest for the German group (30.4 per cent) and lowest for the Polish group (19.0 per cent). With the exception of the German, French-Canadian and colored groups, the variations were confined within a range of less than 5 per cent. Furthermore, these differences did not correspond in all cases to variations in mortality. For example, the Polish and Portuguese groups, though having high death rates, had low proportions of babies born to mothers of these ages, and the German, though having a relatively low death rate, had the highest proportion of babies born to such mothers. On the other hand, the mortality among the Jewish infants tended to be lessened slightly by a low percentage, and that among the French-Canadian infants tended to be raised slightly by a high percentage, of babies whose

mothers belonged to age groups which had high death rates.

The variations in the proportions of births which were of orders fifth and later, for which the mortality rates were above average, were somewhat more marked. These proportions ranged from 19.0 per cent for babies of native white mothers to 42.6 per cent for those of French-Canadian mothers; but exclusive of the native white the percentages had a much narrower range, from 28.3 for the "other foreign" to 42.6 for the French-Canadian group. Except for these two groups, however, the range of variations was within 10 points. The effect of making an allowance for these differences, then, was to raise slightly the figures for the babies of native white mothers and to diminish slightly those for the babies of French-Canadian mothers relatively to the rates for the other groups.

Except for the very low percentage (16.4) for the Jewish group, comparatively little variation in the proportion of births following preceding births at short intervals—as measured by a difference of one year in the mother's ages expressed in even years at the successive births—was found for the several nationalities. Again the range in these percentages was within 10 points, except for the unusually low proportion of such births in the Jewish group. When due account was taken of disproportions in the weighting of the various groups with infants who were born within short intervals after older brothers or sisters, the most noteworthy point discovered was that the mortality among the Jewish infants appeared slightly more favorable as compared with that of other nationalities.

The influence of interval before a succeeding pregnancy was not very important, since of the total months lived from birth until the end of the first year by all the infants in the one city for which this information was obtained only 4.7 per cent, or less than one-twentieth, were lived by infants after their mothers had again become pregnant. The proportion of births to mothers who became pregnant during the infants' first year of life varied from 7.9 per cent in the Jewish to 25.2 per cent in the Italian group. Though these differences, the importance of which the percentages tend to overstate, were not large enough to account for any great variations in the mortality rates for the several groups, the Jewish infants again seemed to have had the most favorable conditions.

So far as such factors as premature birth, single or plural birth, and death of the mother are concerned, variations between the proportions of infants of the different nationality groups who were subject to each of these conditions were comparatively slight, and tended, moreover, to offset one another. The net result, therefore, of eliminating these factors was not significantly to modify the correlations exhibited by the original rates.

The conclusions to be drawn from this analysis are not as definite, perhaps, as might be wished. The two most important complicating factors, economic status and type of feeding, were found partially to neutralize each other. At any rate, the elimination of these items did not by any means remove the variations which in the original results characterized the nationality rates. The only conclusions that can be reached, therefore,

are that some conditions other than those which have been considered in the present study are responsible for marked variations and that these conditions appear, so far as the present study can throw light upon them, to be associated with nationality. But whether the conditions which cause these marked variations are themselves environmental or are to be classed as hereditary in the racial sense can not be determined definitely. Nationality must still be regarded as an important factor in infant mortality, although the exact nature of its influence cannot be stated.

CHAPTER VII

ECONOMIC FACTORS¹

Many writers upon infant mortality have pointed out the correlation that exists between high infant death rates and low economic position.² Such a correlation, however, does not necessarily imply a causal connection. For example, if a larger proportion of births in the low than in the high income groups were fifth and later in order, the correlation with order of birth might account for part of the relationship between low income and high infant mortality. Or, if a much larger proportion of the babies in the low than in the high income groups were artificially fed, such a correlation might be merely a reflection of a high mortality among artificially fed infants. Or, again, if a larger proportion of the babies in the low than in the high income groups belonged to races that were characterized by high infant death rates, such a correlation might be merely a reflection of the high rates prevailing among these races.

¹ Adapted by permission from *Economic Factors in Infant Mortality*, published in the *Quarterly Publications of the American Statistical Association*, Vol. XIX, pp. 137-155, June, 1924.

² See, for example, Prinzing, F., *Handbuch der medizinischen Statistik*, pp. 300-304.

Westergaard, H. *Die Lehre von der Mortalität und der Morbilität, Anthropologisch-Statistische Untersuchungen*, Jena, 1902, pp. 394-402.

Hibbs, H. H., Jr. *Infant Mortality: Its Relation to Social and Industrial Conditions*, pp. 121-127, and others cited *infra*.

On the other hand, the correlation between income and infant death rates may be found to be explained in part by correlations between such rates and employment of the mother, housing congestion and other economic factors. In these cases, if it is shown that employment of the mother and housing congestion are themselves causally influenced by low income, the responsibility of low economic position for high infant mortality is not lessened by the presence of intermediate factors in the chain of causation.

Evidently, therefore, a thorough study of the relation between poverty and infant mortality requires material for and methods of analysis that permit of distinguishing between these and other different possible explanations of any correlation found between the two.

The information available from birth and death certificates which bears upon the economic position of families in which children are born is limited to the father's occupation, from which inferences may be drawn as to his economic status. On this point an analysis of the English statistics for 1911 shows that the mortality rate for legitimate infants in the upper and middle class (76.4) was much lower than in the intermediate (106.4) or in the wage-earning (132.5) class.³ But not only are the occupations difficult to classify according to economic status in many instances, but the procedure of treating all persons having the same occupation as if they had the same economic position tends to obscure any effect which economic

³ Stevenson, T. H. C., 74th Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales, 1911, Cd. 6578, pp. xl-xlv, 73-92, especially p. 88.

position may have. Furthermore, with the limited information available, the elimination of the influence of other factors, such as prevalence of artificial feeding or of a high birth rate, is difficult if not impossible.

In most studies of the subject, therefore, recourse has been had to some indirect method of measuring the influence of economic position. Comparative figures of infant mortality for the different wards of a city or for different cities or districts are correlated with indices of economic status for the same areas. As indices have been used, for example, the average income,⁴ the proportion of domestic servants in the female population,⁵ and the proportion of persons in receipt of poor relief.⁶ Not only are these indices relatively unsatisfactory but also, because of the indirectness of the method, the influence of economic position tends to be obscured and the elimination of other factors, such as type of feeding⁷ or the "birth rate," becomes especially difficult.⁸

⁴ Neefe, quoted in Prinzing, F., *Handbuch der medizinischen Statistik*, p. 302.

⁵ Great Britain. Thirty-ninth Annual Report of Local Government Board, 1909-1910. Supplement to the Report of the Board's Medical Officer containing a report by the Medical Officer on Infant and Child Mortality. Cd. 5263, p. 55.

⁶ Groth, Alfred, M.D., and Hahn, Prof. Martin, M.D., "Die Säuglingsverhältnisse in Bayern." *Zeitschrift d. k. Bayerischen-Statistischen Landesamts*, 42nd year, 1910, No. 1, pp. 78-164, especially p. 101.

⁷ Differences in type of feeding as a possible explanation of the higher mortality found among the babies of the poor are eliminated in some of the studies by evidence that artificial feeding is less prevalent among the poor than among the rich. See, *Infant and Child Mortality*, Cd. 5263, pp. 54-55; Prinzing, *Handbuch der medizinischen Statistik*, pp. 300-304.

⁸ Greenwood, M., Jr., and Brown, J. W., in "An Examination of

The conclusions presented in the present chapter are based upon records for over 21,000 legitimate live births which occurred between November 1, 1912, and December 31, 1915, in seven American cities studied by the United States Children's Bureau.⁹ This material offers a comparatively large mass of data which permits not only of showing the direct correlation between the infant mortality rate and such economic factors as father's earnings, housing congestion, and mother's employment, but also of isolating the influence of each of these factors from that of the others and from that of such factors as type of feeding and race and nationality of mother.

It should be emphasized that the various measurements of social and economic conditions used in the analysis are in every case applied directly to the particu-

Some Factors Influencing the Rate of Infant Mortality," *Journal of Hygiene*, Vol. XII, pp. 5-45, applied to the material secured by Groth and Hahn for rural communes and urban districts in Bavaria the method of partial correlation to separate the influence of the economic factor from those of artificial feeding and the birth rate. Their conclusion, based upon the rural communes alone, was a negative one—that the evidence did not show that the average infant mortality rate in the rural communes varied significantly (i.e., with respect to the probable error) with the average economic position of the commune as measured by the proportion of persons in receipt of relief, when prevalence of artificial feeding and the birth rate were held constant (p. 34).

Reference should be made also to the correlation of cyclical changes in industrial conditions with changes in infant mortality rate. See W. F. Ogburn and Dorothy S. Thomas, "The Influence of the Business Cycle on Certain Social Conditions," *Journal of the American Statistical Association*, Vol. XVIII, pp. 335-337.

⁹ Johnstown, Pa., was omitted from tables showing father's earnings because the classification of earnings used in the report on infant mortality in that city was not exactly comparable with that used in the reports for the other seven cities in the series.

lar infants whose chances of life might be affected. Thus, the data on the father's earnings relate to the amount earned during the year immediately following the baby's birth, that is, during the period when these earnings would be associated most closely with the baby's chances of life; the information on the mother's employment relates to work during the period of pregnancy preceding and during the year following the infant's birth; and housing conditions relate to the house in which the family lived during the infant's first year.

The method of securing the data, so far as they could not be obtained from birth and death records, was by interview with the mother. On most of the questions studied—the infant's feeding, nationality (mother tongue), housing conditions, etc., the mothers were in the best position to give satisfactory information. With regard to fathers' earnings the mothers were asked not only as to the total amount, but also as to wage rates, periods of unemployment and sickness, etc. If discrepancies were found—for example, if the time at work at the stated wages would not have yielded the total amount said to have been earned, or if the mother could not give the information—the data were secured later from the father. In case the father had died or had deserted previous to the birth of the infant or during the year following, the amount used was what he actually earned during that part of the year when he was contributing to the support of the family. In a few cases, therefore, in which the father deserted or died during the year, the amount of his earnings which the family had to live on was much below his normal

earnings for a full year; and in other cases in which the father had died or deserted prior to the birth of the child, he was classified as having "no earnings." These cases were not numerous, but they are mentioned in order to emphasize the fact that the reports of earnings were not, and should not be interpreted as, statements either of yearly wage rates or of total family incomes.

In most of the cities studied the statements of earnings thus secured were not compared with pay-roll data nor was information obtained from employers. In the city of Manchester, however, in which a very large proportion of the fathers of infants included in the study were employed in the textile mills, the mothers' statements of fathers' earnings were compared with the amounts as shown on the pay-rolls. For this city it was found that, although on the whole the statements of the mothers tended to exaggerate slightly the amounts actually received,¹⁰ when the data were classified according to the earnings as stated by the mothers the results were substantially the same as when they were classified according to the amounts derived from the payrolls. The comparison of the results of the two methods of securing information as to earnings in this city seemed to indicate that the data secured in other cities by interviewing the mothers were substantially accurate.

Besides data on the father's earnings, information was secured as to the amounts earned by the mother and by other members of the family, and as to other

¹⁰ Since the material is used simply to show the correlation between earnings and mortality, a uniform error of overstatement would not affect the validity of the conclusion.

sources of income. The information obtained on these points was not considered, however, so reliable as that on the father's earnings. The earnings of mothers, for example, were derived largely from keeping lodgers and boarders, and when this was the source it was difficult to separate the net from the gross receipts. In determining total family income, moreover, not only were net receipts difficult to secure in cases, for example, of income from rents of houses owned but not lived in by the families, but also perplexing questions arose as to whether a given item, for example, money borrowed or money returned, constituted true income. Furthermore, difficulties in comparing incomes arose from the fact that some families may have invested their savings in the homes occupied by them and, though neither receiving nor paying rent, may have incurred various expenses connected with such ownership, while others may have invested their savings in such a way as to secure definite cash incomes. For the purposes of this study the amount which it would have been most desirable to know was the portion of the income spent for the subsistence and maintenance of the family or, better still, the portion actually expended for the infant's maintenance and in ways that would influence the infant's health, including expenditures for the health of the mother. Since, however, this amount could not be ascertained and even the total family income was subject to so much doubt, the data on father's earnings appeared to furnish the nearest approximation to a satisfactory measure of the effect of economic status on infant mortality. These data, therefore, have been used as the principal basis of classi-

fication, a procedure which seems, moreover, as will be shown later, to be justified by the correlation found between father's earnings, total income, and father's earnings per capita of members of the family.

All these data relating to amounts of earnings, it should be emphasized, were secured before the marked rise in prices and wages during and following the war, and since the time from the first to the last study of the series was relatively short—about three years—the figures for annual earnings in the different cities, so far as changes in the level of prices and wages are concerned, may be considered fairly comparable.

Classifying each case according to the earnings of the father during the year immediately following the birth (so far as these earnings were available for the family), table 35 shows a marked relationship between infant mortality and father's earnings. The higher the earnings the smaller the proportion of deaths. For infants whose fathers earned less than \$450 the rate was 166.9, as compared with only 59.1 for those whose fathers earned \$1,250 or over. The group of babies whose fathers were classified as having "No earnings" had the highest rate of all, 210.9.

The distribution of births in the several father's earnings groups is shown also in table 35. A striking fact was the small proportion, only 10.5 per cent, of the infants studied who were born in families in which the father earned more than \$1,250. On the other hand, 41.0 per cent were born in families in which the father earned less than \$650.

In practice the father's earnings, except perhaps in the comparatively small group in which they exceeded

\$1,250, constituted in the vast majority of cases by far the largest part of the family's income, and in fact may be said to have determined its economic status. In Baltimore, for example, only 7 per cent of the

TABLE 35

Infant mortality rates, by cause of death and earnings of father
Live births in seven cities

EARNINGS OF FATHER	LIVE BIRTHS	INFANT DEATHS	INFANT MORTALITY RATES*						NEONATAL MORTALITY RATES†
			All causes	Gastric and intestinal diseases	Respiratory diseases	Early infancy	Epidemic and other communicable diseases	All other causes	
Total.....	21,536	2,368	110.0	32.3	19.2	35.9	6.8	15.7	44.4
Under \$450.....	3,085	515	166.9	60.6	33.4	43.8	12.3	16.9	55.8
\$450 to \$549.....	2,827	355	125.6	44.9	23.3	35.4	6.4	15.6	46.0
\$550 to \$649.....	2,908	339	116.6	36.5	18.9	37.5	9.3	14.4	43.3
\$650 to \$849.....	5,050	543	107.5	27.1	19.6	37.4	5.5	17.8	46.5
\$850 to \$1,049.....	3,345	277	82.8	19.7	13.5	30.2	4.2	15.2	38.0
\$1,050 to \$1,249.....	1,391	89	64.0	8.6	7.9	25.9	3.6	18.0	33.1
\$1,250 and over.....	2,252	133	59.1	8.0	6.2	32.4	2.2	10.2	38.2
No earnings.....	313	66	210.9	86.3	47.9	41.5	16.0	19.2	60.7
Not reported.....	365	51	139.7	41.1	16.4	49.3	16.4	16.4	41.1

* Deaths under 1 year per 1,000 live births.

† Deaths under 1 month per 1,000 live births.

families had any income from insurance, investments, or rents from tenants outside their own dwellings; the proportion was greatest, as would be expected, for families which were classed in the group \$1,250 and

over on the basis of father's earnings.¹¹ In a considerable proportion, 23 per cent, of the families the earnings of the father were supplemented by those of the mother or of children, but the amounts received from these supplementary sources of income were small. In about half the cases the mother's gross earnings were less than \$150. The amounts reported for the children were on an average higher; in about half the cases the total earnings of all the children in the family who worked amounted to \$300 or over. If the classification had been based on family income instead of on father's earnings, about one fifth of the entire number of infants would have been placed in higher groups, but the other four fifths would have been placed in the same groups by either method.

Classifying the births both by father's earnings and by total family income indicated, surprising as it may appear, that in families with equal amounts of father's earnings the infant mortality rate was higher when more was contributed to the income from other sources, in the majority of cases from the earnings of the mother or of older children. This is doubtless explained in part by the influence of the mother's employment in increasing infant mortality, and partly by such factors as high order of birth for infants in families which had children old enough to be employed.

The significance of father's earnings in terms of economic pressure is shown in table 36, which sets forth the correlation between the amount of these earnings

¹¹ See *Infant Mortality: Results of a Field Study in Baltimore, Md., Based on Births in One Year*, by Anna Rochester, U. S. Children's Bureau Publication No. 119, p. 35.

and their distribution per capita of the members of the family. The estimated median per capita income from father's earnings increased from \$101 for the group "Under \$450" to \$338 for the group "\$1,050 to \$1,249."¹²

TABLE 36

Proportion of births in families having per capita income from fathers' earnings of less than \$100, and median income per capita, by earnings of father

Live births in seven cities

EARNINGS OF FATHER	PER CENT OF LIVE BIRTHS IN FAMILIES WITH PER CAPITA INCOME* LESS THAN \$100	MEDIAN PER CAPITA INCOME*
Total†.....	17.1	\$177
Under \$450.....	49.0	\$101
\$450 to \$549.....	30.2	\$129
\$550 to \$649.....	17.7	\$161
\$650 to \$849.....	5.1	\$234
\$850 to \$1,049.....	1.3	\$265
\$1,050 to \$1,249.....	0.1	\$338

* Income from father's earnings only.

† Excludes births in families in which fathers earned \$1,250 and over, or had no earnings, and those in which earnings or number in family were not reported.

¹² In this calculation the group \$1,250 and over was not considered; for the rest the father's earnings in each family were assumed to be equal to the middle amount in the group in which it was classed, thus, \$500 for families in the group "\$450 to \$549," \$600 for those in the group "\$550 to \$649," etc., and the per capita income was found by dividing by the number as reported in each family. For the group "Under \$450" an arbitrary figure of \$400 was set as the approximate average earnings for purposes of this calculation.

Since the average number in the family was slightly greater in the lower than in the higher father's earnings groups, the variations in economic pressure appeared slightly greater than variations in the earnings themselves. In other words, as the father's earnings, which constituted the bulk of the family income, decreased the economic pressure increased at a slightly more rapid rate. In general, the lower the earnings the greater was the economic pressure as indicated by their distribution per capita.

Though the differences between father's earnings groups may, therefore, be taken as indicating differences in average per capita incomes or in average economic pressure, in each group were included some families that would have been placed in a relatively higher, and others that would have been placed in a relatively lower, position on a per capita income scale than on the father's earnings scale. If the families were all classified, therefore, on a per capita income scale, the true influence of economic pressure—or, if extreme, of poverty—as a factor in infant mortality would be more clearly presented.

In table 37 the result of a classification of births by per capita amount of father's earnings is presented for all the infants born in families in which the father earned less than \$1,250, that is, for those groups in which the father's earnings most closely represented family income. The relationship shown by this grouping between economic pressure and the infant mortality rate was even more striking—as indeed would be expected—than when no account was taken of the number of members in the family for whom the earn-

ings had to provide. The conclusion seems justified, therefore, that an analysis based on father's earnings alone yields substantially the same results as an analysis based on father's earnings per capita of his household and gives, in fact, trustworthy evidence as to the relation of economic need to mortality among the infants studied. The following discussion, therefore, runs in terms of father's earnings, except where the number in

TABLE 37

Infant mortality rates, by per capita income from father's earnings
Live births in seven cities

PER CAPITA INCOME FROM FATHER'S EARNINGS	INFANT MORTALITY RATES
Total*.....	113.9
Less than \$50.....	215.9
\$50, less than \$100.....	141.8
\$100, less than \$200.....	123.2
\$200, less than \$400.....	96.1
\$400 and over.....	60.5

* Excludes births in families in which fathers earned \$1,250 and over, had no earnings, or earned amounts which were not reported, and a few cases in which the number in the family was not reported or in which the infant lived in an institution.

the family has to be taken into consideration as one of the items of the analysis.

Not only did the general rates of infant mortality decrease as the earnings of the fathers increased, but, with one or two exceptions, the rates from the several causes, as shown in table 35, exhibited the same tendency. The mortality from gastric and intestinal diseases showed, perhaps, the most marked variation

by earnings, the rate in the lowest earnings group, "under \$450," being seven and one half times that in the highest, "\$1,250 and over."

The mortality from respiratory diseases likewise showed a marked negative correlation with father's earnings. For the infants of fathers who earned less than \$450 the rate was 33.4, as compared with 6.2, less than one fifth as high, for those of fathers who earned \$1,250 and over. As would be expected, the mortality among the babies whose fathers were reported to have had "No earnings" was highest of all.

Similar correlations appeared for the other causes of death. From epidemic diseases the lowest mortality was found to have been in the father's earnings group "\$1,250 and over," and the highest in the two groups "No earnings" and "Under \$450." Likewise from causes peculiar to early infancy the rates for the infants of fathers who had the lowest earnings were higher than for those of fathers who earned \$850 and over.

The correlations just discussed are the total correlations associated with differences in earnings. As already noted, they may arise from a causal relation between poverty and the death of babies or may constitute merely a result of the association of low earnings with greater prevalence of artificial feeding or with other factors that, though not themselves a result of insufficient income, appear to cause high infant mortality. Before concluding that the association of excessive mortality with low earnings proves that a high infant death rate is a direct result of poverty, the question must be answered—Is this correlation due to the influence of other causes? Three other causes or

groups of causes should be considered in this connection: type of feeding, color and nationality of mother, and the group of factors associated with frequency of births.

Since the mortality among the artificially fed infants was found to have been three or four times as high as that among the breast fed,¹³ the inquiry is pertinent in this connection—Was the high rate among infants in families in which father's earnings were low due to an unusual prevalence of artificial feeding in those families? The analysis shows that, on the contrary, the giving of exclusively artificial food was markedly less prevalent in the low than in the high income groups. Of the months lived from birth up to the end of the ninth by babies whose fathers earned less than \$450, 22.0 per cent were months of artificial feeding, as compared with 30.0 per cent of those lived by babies whose fathers earned \$1,250 or over. Evidently, therefore, no part of the excess mortality among infants in the low income groups can be explained by any greater tendency toward artificial feeding in these groups.

Since infant mortality varied markedly in the different race and nationality groups¹⁴ the question should next be examined—Were the infants of the groups in which the mortality rates were high found in disproportionate numbers in the low income groups? The race and nationality groups in which the infant mortality rates were above average, as already shown, were the Portuguese with a rate of 200.3, the French-Canadian with a rate of 171.3, the Polish with a rate of

¹³ See Chapter V.

¹⁴ See Chapter VI.

157.2, the colored with a rate of 154.4, and the group of "other foreign"¹⁵ nationalities with a rate of 129.6. These five groups included 32.3 per cent of all the infants. But the earnings group "Under \$450" included 55.0 per cent of the infants of these five race groups, while the group "\$1,250 and over" included only 10.0 per cent. This markedly disproportionate weighting of the low income groups with infants of races with higher than average infant mortality rates might account, therefore, for part of the tendency toward high mortality in the low income groups.

Nevertheless, that this correlation with nationalities which had high infant mortality rates accounted for but a relatively small part of the excess mortality associated with low earnings is apparent from table 38. In each of the principal color and nativity groups, the native white, the foreign-born white and the colored, the relation between low earnings and a high infant death rate was striking. And among the native white infants alone—a group uninfluenced by any disproportionate weighting with colored or with foreign-born nationalities—the relation between mortality and father's earnings was even more striking than in the entire group studied. Furthermore, the differences between the average mortality rates in the three race and nativity groups appeared to have resulted largely from the unfavorable weighting of the foreign-born white and the colored with disproportionate numbers of infants in the low earnings groups, for the differences between the rates for the infants of

¹⁵ Includes foreign-born nationalities except Italian, German and Jewish and those mentioned in the text.

the foreign born and colored mothers were relatively slight when comparisons were made within groups where earnings were substantially equal. The high rate of 166.9 in the earnings group "Under \$450," for example, was not increased by the inclusion of a disproportionate number of infants of colored mothers,

TABLE 38

Infant mortality rates, by color and nativity of mother and earnings of father

Live births in seven cities

EARNINGS OF FATHER	INFANT MORTALITY RATES			
	Total	Native white	Foreign-born white	Colored*
Average.....	110.0	93.9	123.7	152.3
Under \$450.....	166.9	170.0	167.1	162.7
\$450 to \$549.....	125.6	121.0	118.4	163.7
\$550 to \$649.....	116.6	110.8	121.8	122.8
\$650 to \$849.....	107.5	99.5	119.6	102.7
\$850 to \$1,049.....	82.8	76.4	94.9	
\$1,050 to \$1,249.....	64.0	62.6	68.4	
\$1,250 and over.....	59.1	57.6	60.0	
No earnings.....	210.9	187.5	234.2	
Not reported.....	139.7	154.7	129.5	

* Not shown where base is less than 100.

since the rate for such infants in this particular earnings group was in fact not so high as that for the infants of native white mothers. The conclusion may fairly be drawn, therefore, that the relationship found between low earnings of fathers and high infant mortality was not due to, but was independent of, the correlation between low earnings and color and nativity.¹⁶

¹⁶ A separate analysis of the rates by nationality of the foreign-born group leads to a similar conclusion; namely, that the relation-

The third factor or set of factors which must be considered as having a possible influence in producing the correlation between low earnings and high infant mortality is the group of factors associated with frequency of births, including age of mother, order of birth, interval since preceding birth, and interval before succeeding pregnancy.¹⁷

Low economic status was found to be correlated with each of the four factors associated with birth frequency. The low earnings groups included a disproportionate number of infants of orders fifth and later, of those born to mothers under 20 or to those 35 years of age or over, of those who followed preceding brothers or sisters after short intervals, and of those whose mothers became pregnant during their first year of life—all four divisions which had higher than average mortality rates. In no case, however, was there any very great difference between earnings groups in the proportions of births in these four divisions. The percentages of infants born to mothers under 20 or 35 years of age or over varied only from 30.7 for those whose fathers were classified as having had no earnings to 20.1 for those whose fathers earned \$850 to \$1,049. For short interval births the percentages varied from 29.4 per cent in the group "Under \$450" to 20.4 per cent in that

ship between low earnings and high infant mortality rates was, on the average, practically as marked within each nationality group as in the group as a whole.

¹⁷ No "birth rate" applicable and peculiar to each individual infant can be calculated. The influence of the "birth rate" as a causal factor must, therefore, be of composite character and the joint resultant of the factors, age of mother, order of birth, interval since preceding birth, and interval before succeeding pregnancy.

"\$1,250 and over." For infants whose mothers became pregnant again during their first year of life the proportions varied from 16.1 per cent in the group "Under \$450" to 7.9 per cent in that "\$1,250 and over."¹⁸ The most marked variations were found between the percentages of births of orders fifth and later, which varied from 34.5 in the earnings group "Under \$450" to only 18.1 in that "\$1,250 and over."

Not only were these differences comparatively small, but to a certain extent the four factors, order of birth, age of mother, interval since preceding birth, and interval before a following pregnancy, were interrelated. Births of high orders were commonly to mothers of older ages, and were frequently associated with short intervals.

The problem of isolating the influence of these factors from that of low income over the infant mortality rate offers some difficulty. The most appropriate method of analysis is Westergaard's method of expected deaths which is used in constructing table 39.¹⁹ The first column shows for each earnings group the ratio of actual deaths to deaths that would have been expected if the average rate of infant mortality for all births had prevailed in each earnings group, forming a series of ratios which states simply the total correlation of earnings with the infant mortality rate. The second column shows a series of ratios that expresses the relation between earnings and mortality after the influences

¹⁸ In the "No earnings" group, including families in which the father died or deserted or was sick or unemployed during the entire year, very few, only 1.4 per cent, of the mothers became pregnant during the infant's first year.

¹⁹ For a discussion of this method of analysis, see Chapter IV.

of age of mother and order of birth have been eliminated. A comparison of the second with the first series of figures shows that the correlation between earnings of father and the infant mortality rate was reduced by the elimination of the influence of age of mother and order of birth combined, but that the

TABLE 39

Relative infant mortality by earnings of father, with influence of age of mother and order of birth, and of influence of interval since preceding birth, eliminated

EARNINGS OF FATHER	RATIO OF ACTUAL TO EXPECTED DEATHS*			
	Expected at average rates for single births; seven cities	Expected at rates for same order of birth and age of mother	Expected at average rates for all births; Baltimore	Expected at rates for same interval since preceding birth
Total.....	100.0	100.0	100.0	100.0
Under \$450.....	152.8	142.5	151.4	140.3
\$450 to \$549.....	113.5	108.8	114.0	116.9
\$550 to \$649.....	103.0	101.1	105.1	100.5
\$650 to \$849.....	98.0	98.8	92.8	96.5
\$850 to \$1,049.....	75.4	78.1	69.1	66.1
\$1,050 to \$1,249.....	59.0	61.9	64.3	66.9
\$1,250 and over.....	54.5	59.6	62.5	60.8
No earnings.....	200.0	191.6	200.7	211.4
Not reported.....	130.1	128.6	135.5	131.1

* Per cent.

reduction was relatively slight; the effect of eliminating the influence of these factors did not alter materially the marked correlation between low earnings of father and a high mortality rate. The next two columns of the table show the effect of eliminating interval since the preceding birth; in this case the series of ratios

after the influence of interval has been eliminated should be compared with the series in the third column, which, however, shows a trend quite similar to that indicated in the first column. The effect of eliminating the influence of interval since preceding birth as a factor evidently did not change significantly the excess mortality associated with low income. The correlation between a high infant mortality rate and low income was still as marked as before.

Unfortunately the births for which interval was available included only about half those for which other data were obtained and the number was too limited to permit of eliminating jointly all three influences—age of mother, order of birth and interval since preceding birth. But since the net result of eliminating the last mentioned factor was practically not to alter the trend of the rates by father's earnings, and since the effect of eliminating the other two was slight, the conclusion may fairly be drawn that even after the elimination of all three factors together there would still be found the same marked correlation between low income and high infant mortality.

No attempt was made to eliminate the effect of interval before succeeding pregnancy, since the analysis showed that the possible influence of this factor was limited to less than one twentieth of the months under one year of age lived by all the babies in the study. This influence was found to be due largely to the greater prevalence of artificial feeding among infants whose mothers had become pregnant again during their first year and, therefore, so far as the effect of this factor on the relation between economic status

and infant mortality is concerned, it was offset by the smaller proportions of other babies of the same earnings groups who were fed artificially, with the net result already mentioned that fewer babies of the low than of the high earnings groups were given artificial food.

The evidence indicates, therefore, that the relation found to exist between low earnings and high infant mortality was not to be explained by correlations with type of feeding, with color and nationality of mother, or with factors associated with the frequency of birth, but must be considered to indicate some direct or indirect causal connection.

The influence of the father's earnings upon his infant's chances of life was undoubtedly indirect and was exerted through the relation of the family's economic status to the mother's health and care during pregnancy and confinement, and to the care of the baby during his first year. As already suggested, this influence may be found to be exerted through such intermediate factors as housing congestion or the mother's employment during pregnancy or during the infant's first year, which may be shown partially to account for the correlation between father's earnings and infant mortality. When the meager earnings of the father have to be supplemented by the mother's gainful labor outside the home, the lack of income which is responsible for the mother's employment is, fundamentally, responsible also for whatever increased mortality is found to be associated with such employment.

An intimate connection was found, as shown in table 40, between father's earnings and the amount and qual-

ity of prenatal care in the one city, Baltimore, for which information on the latter points was secured. Thus, 53 per cent of the mothers in the group "Under \$450"

TABLE 40

*Availability of medical and nursing care to mothers of legitimate infants during pregnancy and confinement, by earnings of father; Baltimore, 1915**

EARNINGS OF FATHER	PER CENT OF MOTHERS HAVING NO MEDICAL PRENATAL CARE	PER CENT OF MOTHERS HAVING PRENATAL CARE OF GRADE A†	PER CENT OF MOTHERS NOT ATTENDED BY PHYSICIANS AT CONFINEMENT	PER CENT OF MOTHERS HAVING 10 OR MORE VISITS FROM PHYSICIAN FOLLOWING DELIVERY ‡	PER CENT OF MOTHERS HAVING NO NURSING CARE DURING CONFINEMENT PERIOD	PER CENT OF MOTHERS WHO STAYED IN BED OR IN HOSPITAL LESS THAN 7 DAYS FOLLOWING DELIVERY
Total.....	47.5	5.1	32.6	15.6	28.6	8.1
Less than \$450.....	53.0	1.3	35.7	8.9	37.2	12.8
\$450 to \$549.....	58.7	1.8	43.6	8.2	30.1	11.8
\$550 to \$649.....	59.8	1.6	43.7	9.2	29.9	
\$650 to \$849.....	52.7	3.5	36.6	14.5	30.4	7.1
\$850 to \$1,049.....	40.5	6.6	27.9	20.7	26.0	4.2
\$1,050 to \$1,249.....	30.0	8.2	18.1	24.1	25.0	3.4
\$1,250 to \$1,449.....	32.9	9.2	19.1	26.9	19.8	2.4
\$1,450 to \$1,849.....	21.3	16.4	8.5	40.1	15.1	1.7
\$1,850 and over.....	13.8	30.3	6.6	40.3	7.5	
No earnings.....	41.4	1.7	22.0	8.2	34.9	7.3
Not reported.....	39.7	4.2	25.1	15.7	31.0	7.3

* These percentages are based upon mothers of legitimate births in Baltimore in 1915.

† To qualify as grade A care, the care received by the mother must have satisfied all four of the following requirements: (1) Monthly visits to clinic from fifth to ninth month of pregnancy or supervision by private physician from the fifth to the ninth month; (2) monthly urinalysis from the fifth to ninth month; (3) at least an abdominal examination; (4) pelvic measurements, if a primipara.

‡ Exclusive of mothers with complications of confinement.

had no medical prenatal care, as compared with only 13.8 per cent of those in the group "\$1,850 and over." And of the mothers in the lowest earnings group 35.7 per cent were not attended by a physician at confinement, as compared with only 6.6 per cent of those in the highest. Similarly with regard to nursing care during the confinement period; 37.2 per cent of the mothers in the lowest, as compared with only 7.5 per cent of those in the highest, group had no such care. The proportion of mothers who stayed in bed or in a hospital for less than seven days following delivery varied from 12.8 per cent in the lowest to 1.7 per cent in the highest earnings group.

Though ignorance in the poorer families of the rules of health doubtless played some part in producing these differences, the obvious relation between lack of means and inability to purchase medical and nursing services and competent advice and to follow out that advice suggests that lack of means or economic pressure must have borne a heavy responsibility. The health program recommended by the best medical authorities for pregnant women includes wholesome and nourishing food, spending at least two hours daily in the open air, and freedom from worry and overwork. This program is obviously one which can be more easily and faithfully observed by women in comfortable circumstances than by those who have to struggle daily to make ends meet.

One item of considerable importance from the point of view of the mother's health and her observance of this health program is her employment away from home during pregnancy. A close relationship was

found to exist between low earnings of the father and such employment. The proportion of mothers employed away from home during pregnancy was highest, 37.4 per cent, in the "No earnings" group, was 28.3 per cent in the group "Under \$450," and was lowest, 1.9 per cent, in the group "\$1,250 and over."

The influence upon infant mortality of employment of the mother during pregnancy is shown in table 41.

TABLE 41

Infant mortality rates from all causes and from causes peculiar to early infancy, neonatal mortality rate, and per cent of premature births, by employment of mother during pregnancy

Live births in eight cities

EMPLOYMENT OF MOTHER DURING PREGNANCY	LIVE BIRTHS	INFANT DEATHS	INFANT MORTALITY RATE			PER CENT OF PREMA- TURE BIRTHS
			From all causes	From causes pecu- liar to early infancy	In first month (neo- natal rate)	
Total.....	22,967	2,555	111.2	36.1	44.8	5.0
Employed away from home.....	3,084	543	176.1	50.3	67.2	6.1
Employed at home.....	3,788	434	114.6	27.2	33.6	3.5
Not employed.....	16,089	1,576	98.0	35.6	43.2	5.2
Not reported.....	6	2				

The infants of mothers who worked away from home had a markedly high rate of mortality from causes peculiar to early infancy, a fact which is shown not only in the specific rate from these causes but also in an excessively high neonatal mortality rate. Furthermore, the proportion of premature births was considerably higher than the proportions either for mothers employed at home or for mothers not employed.

The infants of mothers who worked in gainful occupations at home, on the other hand, had a mortality rate from all causes slightly higher than that among the infants of mothers who did not work at all; but the rate from causes peculiar to early infancy, the neonatal mortality rate, and the percentage of premature births were all below those for infants of mothers who were not employed. This somewhat unexpected result may be due in part to the fact that the amount and character of work done by the mothers who kept lodgers or boarders were not essentially different from those involved in performing ordinary household and family duties, and in part, perhaps, to a tendency on the part of mothers who were not in the best physical condition or who were in ill-health not to work at all. The group of mothers who were not at work may therefore have been somewhat unfavorably weighted by mothers who would have been in one of the other groups if they had enjoyed normal health. That the infants of mothers who were employed away from home during pregnancy showed higher mortality rates than those of mothers who were not so employed or were not employed at all is, in any case, significant evidence of the influence of this type of mother's employment.

Specific evidence in regard to the correlation between poverty and the quality and quantity of care which the baby received during his first year was difficult to secure, and was limited to a few points, such as feeding, housing congestion, and the gainful employment of the mother, especially away from home.

A principal element of infant care, maternal nursing during the first nine months, has already been dis-

cussed; artificial feeding was less practiced in the lower than in the higher earnings groups. As to the quality of artificial food used by the several groups, specific evidence unfortunately is lacking. The analysis indicated, however, that artificial feeding was fraught with greater dangers to the baby's health in the lower earnings groups. Doubtless such feeding as practiced in the families with larger incomes was accompanied by safeguards that were not employed to the same extent in the poorer families. These safeguards probably included the use of pure milk, the practice of proper sterilization of bottles and nipples, the advice of a competent physician in regard to a suitable milk modification formula and his supervision over the feeding of the baby, and the purchase and correct utilization of the ingredients and medicines prescribed. Each of these safeguards, however, involves the expenditure, if not of money, at least of the mother's time; and therefore their use, other things being equal, would naturally be intimately associated with the income available for the care of the infant.

That differences in the safeguards surrounding the practice of artificial feeding did not explain fully, however, the greater mortality among the infants whose fathers' earnings were comparatively low is shown by the fact that a contrast similar to that between the rates for the artificially fed was also found between those for the breast-fed babies in the several earnings groups. Other causes of fewer deaths among the babies whose fathers had the higher earnings doubtless included the greater availability of nursing and medical services. In such families, too, the mothers probably

were freer from household cares, either because of the employment of servants or because of the use of mechanical aids to work, and as a consequence had more time to care for their babies.

A striking correlation was found between low income and housing congestion. To test this relation the deaths of infants under two weeks of age were omitted, since it is doubtful whether housing congestion could have been a factor in these deaths. Of the infants who survived for at least two weeks and whose fathers earned less than \$450, 72.2 per cent, as compared with only 17.5 per cent of those whose fathers earned \$1,250 or over, were found in families which lived one or more persons per room. The significance of this correlation becomes evident when the rates of mortality are considered; in families which lived less than one person per room the infant death rate was only 52.1, as compared with 94.9 in families which lived one but less than two persons per room and with 135.7 in families which lived two or more persons per room. Since housing congestion is one of the consequences following in the train of low earnings, the latter must bear the responsibility for the high mortality caused by the former.

Markedly greater proportions of mothers were employed during their infants' first year of life in the low than in the high income groups. The proportion of mothers employed away from home was highest, 38.0 per cent, in the "No earnings" group, was 19.6 per cent in the group "Under \$450," and was lowest, 0.6 per cent, in the two groups "\$1,050 to \$1,249" and "\$1,250 and over." As in the case of employment during pregnancy, the higher earnings groups had very

few mothers employed away from home. But in each group a much smaller proportion of mothers was found to have been employed away from home during the infant's first year than was found to have been so employed during pregnancy. Nevertheless, the mother's employment away from home during the baby's first year of life was found to have been associated with a mortality 1.6 times the average rate for babies in the same father's earnings groups.

To summarize, in this group of legitimate city births a marked correlation was found between low earnings of father and high infant mortality. Low earnings of the father were found to correspond to high economic pressure as measured by the per capita amount of earnings available for each member of the family. This relationship between earnings and mortality was found to be independent of type of feeding, of race and nationality, and of the factors involved in frequency of births. The conclusion may be drawn, therefore, that economic pressure due to low father's earnings is a causal factor in the infant death rate.

The influence of economic position is undoubtedly indirect. The study of the chain of causation connecting poverty with high infant mortality showed that the responsibility of low earnings extended over the excessive mortality associated with housing congestion and with the mother's employment both during pregnancy and during her child's first year of life. It showed also that a direct relation existed between lack of means and the kind of care available both for the mother during pregnancy and confinement and for the baby during his first year. The analysis suggests,

therefore, that lack of care is another intermediate factor.

The presence of these intermediate factors in the chain of causation, though it does not relieve the economic factor of its present responsibility for high infant mortality, suggests that the chain may be broken through measures that will make the intermediate factors independent of the amounts of money available for family expenditures. Such measures as the free provision of adequate prenatal and confinement care for mothers and of medical supervision over infants through municipal health centers or clinics, if available to all without reference to their economic position, would tend, if thoroughly carried out, not only to reduce the infant mortality rate but also to lessen, if not to eliminate, its dependence upon economic position. Similar results, moreover, would be anticipated from the prohibition of the work of mothers during those periods when it has the greatest adverse influence upon infant mortality, together with such special subsidies as would make such work unnecessary. This dependence is to be regarded not as an immutable verity but as a consequence of the fact that at present the health and care of infants depend upon the resources available in each family and that, therefore, particular conditions that may in a given case reduce or destroy such resources may place the infant's life in jeopardy.

CHAPTER VIII

INFANT MORTALITY AND PREVENTIVE WORK IN NEW ZEALAND¹

New Zealand's infant mortality rate for its white population, 40.2 in 1924, is the lowest for any country in the world.² The rate for the United States birth registration area during the same year, in spite of the marked reduction which has taken place since 1915, was 70.8, or seventy-five per cent higher. New Zealand, therefore, possesses great interest for students of infant mortality.

What are the causes of this exceptionally low infant mortality rate in New Zealand? Has the rate always been as low as at present? Should its low position be ascribed mainly to especially favorable local conditions or to an unusually healthy and vigorous stock selected through the hardships and rigors of immigration to a new land? If the present low rate is of recent origin, to what causes is the decrease to be ascribed? What influences have been exerted by health measures or by special infant welfare work?

In the present chapter the statistics of the decline in infant mortality from the various causes of death are analyzed to throw light upon these questions. A

¹ Adapted by permission from the Transactions of the Eleventh Annual Meeting of the American Child Hygiene Association, St. Louis, October 11-13, 1920, pp. 194-212.

² The statistics are exclusive of the native, or Maori, population for which registration of births and deaths is still imperfect.

brief survey is presented of local conditions which favor health, including conditions which permanently favor low mortality and those which have been progressively more favorable,—so far as these conditions can be approached statistically. Since comparisons of conditions in different countries, so far as they might explain differences in infant mortality rates, are both extremely difficult and untrustworthy because of the impossibility of surmounting all difficulties, no analysis of this kind is attempted: in particular no attempt is made to test the hypothesis that New Zealand is peopled by an unusually healthy selected stock. In lieu of these alluring but statistically unpromising topics, the reader's attention is invited to an analysis of the relation between the decline in infant mortality and the progress of infant welfare work; for this analysis throws into clear relief the influence of the latter over the remarkable position which New Zealand has won in her control of infant mortality.

DECLINE IN INFANT MORTALITY, 1872-1924

Table 42 shows the decline in infant mortality in New Zealand from 1872 to 1924. In order to eliminate fluctuations, rates are given only for five year periods. In 1872-1874 the rate was slightly higher than the 1915 rate for the United States birth registration area. It declined during a period of 50 years to less than one half its former size.

During the first five-year period the mortality rate decreased 4 per cent, and during the next, 10 per cent; from this point to about 1899 the fall was relatively slight. But after 1900 it became more rapid; the five-

year period from 1900 to 1904 showed a decline of 7.7 per cent from the preceding period; during the next period the percentage of decrease was 8.8; and during the next 18.1. After the period 1910-1914 the rate of decline fell, at first slightly to 14.7 in 1915-19 and then more rapidly to 8.4 in the last five-year period.

In interpreting this decrease it should be mentioned that, from the point of view of prevention, a fall of 10

TABLE 42

*Decline in infant mortality rates, by periods; New Zealand, 1872-1924**

PERIOD	AVERAGE ANNUAL INFANT MORTALITY RATE	AMOUNT OF DECREASE	PER CENT DECREASE
1872-1874	105.9		
1875-1879	101.5	4.4	4.2
1880-1884	91.4	10.1	10.0
1885-1889	86.3	5.1	5.6
1890-1894	85.6	0.7	0.8
1895-1899	82.7	2.9	3.4
1900-1904	76.3	6.4	7.7
1905-1909	69.6	6.7	8.8
1910-1914	57.0	12.6	18.1
1915-1919	48.6	8.4	14.7
1920-1924	44.5	4.1	8.4

* Compiled from Vital Statistics of the Dominion of New Zealand.

points in the rate of mortality is more easily secured when the initial rate is 100 than when the initial rate is only 60. The marked increase in the rate of fall from 1905 to 1919 is therefore all the more noteworthy. The slackening rate of decrease observed in the final period should be interpreted, as will be pointed out in the discussion of causes, in the light of the remarkably low rates already reached.

Turning to the analysis of the fall in infant mortality by cause of death, table 43 shows infant mortality rates for the several groups of causes. In order to eliminate

TABLE 43
*Decrease in infant mortality rates, by cause of death, New Zealand, 1872-1924**

PERIOD	DEATHS UNDER 1 YEAR PER 1,000 BIRTHS											
	Epidemic diseases (1-19)	Tuberculosis (28-35)	Veneral diseases (37, 38)	Encephalitis, meningitis, and infantile paralysis (60, 61, part 63)	Respiratory diseases (86-98)	Gastric and intestinal diseases (102-110)	Infantile convulsions (71)	Malformations (150)	Early infancy (151-153)	External causes (155-186)	Other defined (—)	Ill-defined (187-189)
1872-1874	14.7	4.7	0.2	1.7	12.5	23.2	10.0	0.6	23.6	1.4	10.5	2.3
1875-1879	8.8	5.7	0.3	1.6	12.3	22.3	8.2	1.5	24.2	2.0	13.7	1.2
1880-1884	7.9	5.0	0.3	1.3	12.2	18.0	7.9	1.4	23.1	1.9	12.0	0.3
1885-1889	6.4	4.2	0.4	1.3	10.8	20.0	6.7	1.2	25.7	1.8	7.4	0.4
1890-1894	10.2	3.3	0.5	1.3	11.3	17.0	6.4	1.2	25.0	1.8	7.7	0.2
1895-1899	5.7	3.1	0.6	1.2	10.4	18.5	6.4	1.6	26.1	2.0	7.0	0.2
1900-1904	5.2	1.8	0.5	1.2	10.0	16.0	4.5	1.6	27.0	2.2	6.1	0.1
1905-1909	3.9	1.4	0.5	1.3	8.4	15.5	3.6	1.4	26.6	2.0	4.8	0.1
1910-1914	2.4	0.9	0.4	1.4	5.8	10.0	2.5	3.0	27.0	0.7	2.8	0.1
1915-1919	2.5	0.4	0.4	1.1	4.5	5.3	2.1	4.1	25.2	0.6	2.3	0.1
1920-1924	1.7	0.4	0.3	0.8	4.5	3.8	1.5	4.9	24.7	0.6	1.6	0.1

* The figures under the causes of death refer to the International List numbers included in each group. For 1923 and 1924 the revised list of causes of death was used. The numbers of the revised list included under each caption were: epidemic diseases, 1-21, 25; tuberculosis, 31-37; venereal diseases, 38-40; encephalitis, meningitis and infantile paralysis, 22-24, 70, 71, part 73; respiratory diseases, 97-107; gastric and intestinal diseases, 111-119; infantile convulsions, 80; malformations, 159; early infancy, 160-163; external causes, 165-202; and ill-defined causes, 204-205.

minor fluctuations, rates are given, as before, for five-year periods.

One of the most important causes of decline in the general death rates for all ages since the seventies of the past century has been the gradual control of epidemic and infectious diseases. The effect is shown in the group of diseases classed as epidemic, including scarlet fever, whooping cough, diphtheria, and measles. This group shows for infants in New Zealand a rapid fall from 14.7 in 1872-1874 to 8.8, 7.9, and 6.4, respectively, in the three following five-year periods. In 1890-1894 the rate from these diseases went up to 10.2, probably owing to an epidemic of influenza, but since then it has fallen to 5.2 in 1900-1904, and to 2.4 in 1910-1914. In 1920-1924 it was only 1.7,—less than one-ninth of the rate in 1872-1874.

Tuberculosis also showed a marked decline as a cause of infant mortality as early as the eighties and nineties. From 5.7 per 1,000 births in 1875-1879, the rate fell in 10 years to 4.2 and in the next 10 years to 3.1; in the period 1905-1909 it reached 1.4, and in the last 5-year period it was only 0.4. In other words, during this 40-year period the mortality from tuberculosis was reduced from nearly 6 per 1,000 to four-tenths of 1 per 1,000 births.³

The mortality from venereal disease—syphilis—showed an apparent increase from 0.2 in 1872-1874 to a maximum of 0.6 in 1895-1899. From this point the

³ In the earlier years of the period under review deaths from hydrocephalus were included under tuberculosis; in the later years they were classed to malformations. See, Neale, Edward P., A New Zealand Study of Infant Mortality, *Journal of the American Statistical Association*, Vol. XX, September, 1925, p. 359.

rate fell slowly to 0.3, or one half as high as in 1895-1899, in 1920-1924. Doubtless throughout the period the mortality from this cause was much understated, owing to unwillingness to certify to the facts in such cases.

The mortality from the group "encephalitis, meningitis, and infantile paralysis"⁴ also showed little change. A slight fall appeared from 1872-1874 to 1880-1884, but after that time there was little or no significant change.

The infant mortality rate from convulsions decreased from 10.0 in 1872-1874 to 1.5 in 1920-1924. This decrease was doubtless due in part to a gradual improvement in the assignment of deaths to the real causes instead of to the final symptoms, and in part to an actual decrease in the death rate from the real causes themselves.

The mortality rate from external causes remained practically constant from 1872-1874 to about 1905-1909. From 2.0 in the latter period, the rate diminished to 0.6 in 1920-1924. The spread of prohibition in local areas and the increasing control over the liquor traffic may have had an influence in diminishing infant mortality from these causes.

"Other defined causes" showed a fairly steady decline from a rate of 12.0 in 1880-1884 to one of 1.6 in 1920-1924.

The rate for causes ill-defined or unknown diminished from 2.3 per 1,000 births in 1872-1874 to 1.2 in 1875-

⁴ In the earlier years the term "encephalitis" was frequently returned in death certificates, probably meaning either meningitis or poliomyelitis.

1879, and to an insignificant figure in the following periods, as the certification of causes of death became more accurate.

Coming now to the more important groups of causes of death among infants, the gastric and intestinal diseases, the respiratory diseases, and the causes peculiar to early infancy will be taken up in order. The group of gastric and intestinal diseases⁵ is by far the most deadly to infant life, with the single exception of the causes peculiar to early infancy. The decline in mortality from diarrhea and enteritis is, therefore, worthy of especial attention. In the period 1872-1874, the rate of mortality from these diseases was 23.2 per 1,000 births. With some fluctuations the rate fell gradually to 15.5 in the period 1905-1909, a decline of 7.7 points in 35 years, or an average of 1 point every 5 years. From this period the fall was rapid. In the next 5 years the mortality decreased by 5.5 points, and in the following five years by 4.7 points more, approximately one point every year. In 1920-1924 the rate was only 3.8 and in 1923, it may be noted, it was only 2.6 per 1,000 live births.⁶ Between the period 1905-1909 and

⁵ In this discussion the group of gastric and intestinal diseases includes International List numbers 102-110 (revised list, 111-119).

⁶ It should be mentioned in passing that the dates for changes as given do not pretend to be exact. In order to show more clearly the trend of the rates, averages for five-year periods have been taken, and it is therefore difficult to state, for example, if the average for 1905-1909 is lower than that for 1900-1904, the exact year in which the decrease first took place. This is further complicated by fluctuations in temperature and weather conditions. Even with no causes tending toward a reduction in infant mortality, the rates vary from year to year with variations in temperature; hence, if it is sought to find the exact point at which a decrease commenced, it is necessary to take account of these variations during the period within which the decrease first appeared.

the year 1924 the mortality from gastric and intestinal diseases was reduced by over four-fifths.

A continuation of the decrease of one point a year, which prevailed from the period 1905-1909 until the period 1915-1919, in the infant death rates from gastric and intestinal diseases would have resulted, by the end of the period 1920-1924, in a rate of practically zero. It is not surprising, therefore, that the rapidity of fall slackened, during the last period, to about one point every two years. As a presage of the possible future course of this rate it should be mentioned that in Dunedin, where infant welfare work has been, perhaps, most intensively carried on, no deaths occurred from gastric and intestinal diseases during three successive years, 1922, 1923 and 1924; in other words the rate actually equalled zero.

The mortality from respiratory diseases in 1872-1874 was 12.5 per 1,000 births. For 10 years it maintained approximately this rate; then it decreased gradually in the next 20 years to 10.0 in 1900-1904. From this point the decrease became more rapid. In 1905-1909 the rate was 8.4; in 1910-1914, 5.8; and in 1915-1919, only 4.5. During these 15 years the rate was cut in two. The average annual decrease in this rate during these 15 years was over three times the average annual decrease during the preceding 20 years. The rate in 1920-1924 was 4.5, the same as in 1915-1919.

The mortality from the third group of causes, those peculiar to early infancy, showed no such tendency to rapid fall. It rose from 23.6 in 1872-1874 to 27.0 in 1900-1904, an increase which may perhaps be explained by improvement during this period in the

registration of deaths at very early ages. The maximum, 31.2, was reached in 1902. At this point a change in the trend appeared; the rate fell slightly during the next 5-year period to 26.6, but during the following period appeared to rise to the same figure, 27.0, as in 1900-1904. Nevertheless, the high point which occurred in 1913 was only 28.4, and it is probable that this figure was influenced by the new regulations for compulsory registration of stillbirths which went into effect in that year. The enforcement of registration of stillbirths would lead to a more careful and accurate distinction between births and stillbirths, resulting, doubtless, in the registration since 1913 of a small number of infants who formerly would not have been registered. The further course of the rate tends to indicate a definite improvement, though relatively slight, in the mortality from causes peculiar to early infancy. In 1915-1919 the rate had fallen to 25.2 and for the last period it was 24.7. But in 1924 the remarkably low figure of 20.7 was recorded.

The rate from malformations showed little change between the period from 1875 to 1879 and that from 1905 to 1909, averaging about 1.4. It rose in 1910-1914 to 3.0 and in 1920-1924 to 4.9. As in the case of early infancy a marked increase in the rate first appeared following the passage of the law requiring the registration of stillbirths. It seems probable, therefore, that the increase in the rate from malformations was influenced by the more accurate distinction between births and stillbirths.³

In the analysis of the fall in the infant mortality rates in New Zealand three periods may be distin-

guished. The first is from 1872 to about 1905; during this period the fall in the mortality from epidemic diseases, convulsions, tuberculosis, and ill defined causes was continuous and rapid, and the fall in the mortality from gastric and intestinal and respiratory diseases was slight. The second period is from about 1905 to 1920, during which the fall in the mortality from gastric and intestinal diseases proceeded at a rate five times as great, and that from respiratory diseases decreased over 3 times as fast, as during the preceding period. During these 15 years, the mortality from gastric and intestinal diseases was reduced to one-fifth its former rate, and that from respiratory diseases was cut in half. The third period, from about 1920, shows the beginning of a marked tendency for the rate of fall to slacken owing to the practical elimination of two or three of the principal causes of death, control over which had already been substantially won. In the mortality from the principal remaining important group of causes of death, the diseases of early infancy, a slight decrease since about 1900 is perceptible, and this decrease appeared in 1924 to have become more marked.

This decrease in infant mortality rates is not due merely to an improvement in birth registration, since in such case the rates from each cause of death would be affected uniformly. The analysis has shown that the decreases in the rates from different causes are quite different. Furthermore, compulsory registration of births in New Zealand dates from 1855, or 20 years before the period covered by these figures, while voluntary registration had been fairly satisfactory even

before compulsory registration was enforced. Ninety-eight per cent of the people of the Dominion were born in British possessions, and consequently the population is homogeneous and accustomed to the requirement of birth and death registration. Birth certificates have been used in New Zealand as proof of age in entering school, securing employment certificates, and for other purposes, and the population is therefore thoroughly familiar with the need for adequate registration of births.

CONDITIONS FAVORING LOW INFANT MORTALITY

A brief summary of the general conditions in New Zealand which might have a bearing upon low rates of infant mortality is next in order.

The climate of New Zealand is exceptionally favorable to a low infant mortality rate. New Zealand is a country about one-thirtieth the size of the United States, consisting of two islands⁷ which are together approximately one thousand miles in length and one hundred miles in breadth. The breadth of course varies: At Auckland on the North Island, the land is only 8 miles in width; the greatest breadth is not over 180 miles. The climate of New Zealand is therefore insular throughout, and the temperatures are almost everywhere moderated by sea breezes. The maximum temperature in summer in Auckland rarely rises above 81 degrees, and it is very little higher in the other principal cities. The coldest temperature in Dunedin, farthest south of the larger cities, rarely falls below freezing, and the coldest temperature on record is only

⁷ A third island is comparatively very small.

28 degrees. The consequence is that weather conditions in summer are extremely favorable to a low mortality from gastric and intestinal diseases, and the mildness of the winter is favorable to a low mortality from respiratory diseases. In such a climate there is no tendency to live in close, over-heated rooms.

These favorable climatic conditions are accompanied by favorable housing conditions. Throughout New Zealand, even in the four largest cities, which range in size from about 70,000 to 160,000 population, dwelling houses are for the most part one-story bungalows or cottages, each set in its own plot of ground and provided with a lawn and garden. Tenement and even apartment houses, such as are so prevalent in American cities, are practically unknown in New Zealand. The buildings in New Zealand are mostly of wood, and in architecture unpretentious, but, as generally in new countries, there is plenty of space. Comparatively little manufacturing is carried on, and even in the larger cities there is little or no pollution of the atmosphere from smoke.

In this connection may be mentioned also the comparatively favorable economic level of the population. Little or no real poverty exists. The average rate of wages is high in comparison with the cost of living. Unskilled workmen probably receive somewhat more in proportion to skilled workmen than in this country. The proportion of homes owned is similar to that in this country as a whole; but the proportion of homes owned in the four larger cities is above that in almost any of the large cities in this country, being slightly more favorable than the proportion in Los Angeles.

In regard to improvements in housing and economic conditions in general, it is difficult to bring satisfactory evidence. Presumably the conditions of living have been growing easier as the privations and discomforts of pioneering have given place to the conveniences of a more settled life. The growth of cities has, until recently at least, taken place without any serious crowding of population into inadequate quarters. In regard to wages, it should be mentioned that an era of prosperity up to about 1885 was followed by a prolonged depression which lasted for 10 or 15 years, during which emigration exceeded immigration; since that date prosperity has returned and immigration has been flowing into New Zealand except when prevented by war conditions.

In 1893 a system of compulsory conciliation and arbitration was adopted to regulate wages without the necessity of resorting to strikes. Under this system minimum wages are determined by conciliation boards or councils, or by the arbitration court. This has brought about an increase in wages of the unskilled and lowest paid labor. The evidence goes to show that the wages of unskilled labor have risen relatively to skilled labor. From 1900 to 1918 there has even been a slight increase in wages as compared with cost of living.

In this connection mention should also be made of the land legislation adopted in 1893 and later by which provision was made for leasing on liberal terms lands still held by the Crown, and in particular for splitting up large estates for the benefit of persons seeking to take up land.

The favorable conditions already mentioned may go far toward explaining the low infant mortality rate in New Zealand. Favorable climate alone, however, cannot explain the decrease in the rates. It should be interpreted, rather, as a condition in which measures of prevention will produce larger results, and, therefore, appear more effective, than they would in communities where the climate was not so good. The favorable housing and economic situation may be interpreted in part in the same way, as presenting conditions under which direct measures of prevention will produce large apparent results; but in so far as improvements in these conditions have taken place, they may themselves be factors in the decrease in the rates.

FACTORS IN REDUCTION OF INFANT MORTALITY

Among the general measures of public health and welfare, three in particular merit especial consideration in connection with the reduction in infant mortality. These are the laws regulating midwives and nurses and establishing state maternity hospitals, the protection of children boarded out apart from their mothers afforded by the Infant Life Protection Act, and the infant welfare work of the Royal New Zealand Society for the Health of Women and Children.

MATERNITY AND NURSING CARE

Beginning in 1901 the Department of Public Health in New Zealand has paid special attention to the problem of provision for maternity and nursing care. In 1901 the Nurses' Registration Act was passed. This Act set up standards for nursing training in connection

with optional registration of approved nurses. A four years' course of training in an approved hospital was required for registration. Though registration of nurses is not compulsory, registered nurses are given preference in filling vacancies in hospitals under the control of Hospital and Charitable Aid Boards. Since the law was enacted the number of nurses on the register has gradually increased until in 1925, 3,994 nurses were registered.

Registration of midwives was first required under the Midwives' Act of 1904. Persons who had already been practicing for a period of at least 3 years at the time the law went into effect were entitled to registration without examination, provided they satisfied the registrar they were of good character. The act provided for the granting of certificates to registered nurses who had attended lectures at a State Maternity Hospital or other approved institution for a period of at least 6 months, and to pupil nurses who had attended such lectures for a period of at least 12 months, provided in all cases that they had attended at least 20 cases of confinement and passed a satisfactory examination.

Registration of midwives is compulsory. Notice of intention to practice must be given annually to the registrar. Registration may be cancelled in case of conviction for an indictable offense, or in case of malpractice or misconduct. The Board of Health publishes rules for the guidance of midwives, which set forth in detail the equipment required and the conditions under which medical help must be sent for. If a midwife neglects or refuses to send for a doctor in the cases specified, her registration as midwife is liable to cancellation.

Persons not registered as midwives who practice or use the name of midwife are liable to a fine not exceeding 30 pounds (\$146). This penalty does not apply to assistance rendered in cases of emergency. The Department of Health, when it receives information through the office of the registrar of births or in some other way that a woman not registered as a midwife has attended at a confinement, notifies her of her liability to fine under the law and may prosecute unless she can show that the case was in the nature of an emergency.

In 1925 the total number of registered midwives was 2,110 of whom over six-sevenths, 1,872, had been trained and certified since the passage of the act.

Under the Midwives' Act of 1904 the establishment of one or more state maternity hospitals was authorized. They were designed to provide facilities for the training of midwives and maternity nurses. The first of these state maternity hospitals, or St. Helens Hospitals, as they are called, was opened in Wellington in the year 1905. Three others were opened during the next two years in the other principal cities, and recently three more have been established. Wives of working men who have incomes of less than £4 (\$19.44) a week may avail themselves of the hospital services.

These hospitals not only provide inexpensive care for the confinement period, but also give a small amount of prenatal care for expectant mothers and of postnatal care for infants. These phases of their work, however, are not systematic.

During the year ended March 31, 1925, 2,015 confinements took place in the seven State Hospitals, and 702 confinements which occurred outside of the hospi-

tals were attended by hospital nurses. Of the total births in New Zealand, one in every fourteen took place in a St. Helens Hospital; including those outside the hospitals but attended by their nurses, one in every ten was attended by a St. Helens nurse.

The proportion of births attended by nurses from these institutions is much higher in the cities themselves. Comparing the confinements in the hospitals with the number of births in the urban centers it would appear that 26.2 per cent, or slightly over one-fourth, of the births were attended by St. Helens nurses. This comparison, however, overstates the true proportion, since in the figures for the births in the urban centers births to mothers who live outside the urban areas are deducted from the births assigned to the cities. Many mothers come in from the surrounding country districts to avail themselves of the hospital accommodations of the cities.

The work of the St. Helens Hospitals and the gradual raising of the level of maternity care is a factor which may, perhaps, be related to the decrease since 1900 in the mortality from diseases of early infancy.

INFANT LIFE PROTECTION

The second important phase of preventive and welfare work is the system of infant life protection. The Infant Life Protection Act was first passed in 1896. It provided that infants under 4 years of age boarded out for reward apart from their mothers should be placed only in licensed homes.

The powers of licensing and inspection were at first given to the police. It might be mentioned that this

act was first passed on account of the discovery of a flagrant case of baby-farming in which, after the premium had been paid, the infants boarded out had been practically murdered.

In 1906, in order to improve the system of licensing and inspection, these powers were transferred from the police to the Education Department. At the same time the age of infants to whom the provisions of the act applied was increased to 6 years. Under the Education Department the inspectors are all trained women with nurses' certificates.

The numbers of children boarded out in foster homes ranged from about 700 to 900 during the early years of the act, and since the raising of the age limit the numbers have risen to about 1,200.

The great majority of these children are illegitimate and a large number of them are under 12 months old. Of all the illegitimate children born, about one-fifth are boarded out, and are therefore brought under the protection of this act. Between 4 and 5 per cent of all births are illegitimate.

On account of the absence of data, no comparison can be made between the infant mortality rates before and after the enactment of this legislation.

During the period in which the law was administered by the police, a slight fall in mortality among the children boarded out appears to have taken place. Since the work of licensing and inspection was taken over by the Education Department the mortality has been largely reduced. The deaths per 1,000 of average infant population under one year of age in foster homes decreased from 143 in 1908 to 21 in 1918. In institu-

tions operating under special provisions of this act, the deaths per 1,000 infants under one year of age who were in the institutions at any time during the year decreased from 236 in 1909 to 36 in 1919. Neither of these figures, of course, are "infant mortality rates" but probably they give a fair indication of the decline in mortality among children under one year.

Statistics of mortality among all illegitimate children are available for New Zealand only since 1921. The average rate, 70.5, for 1921-24 for illegitimate infants compares unfavorably with a rate of 42.0 for legitimate infants. Probably the infant mortality rate among illegitimate infants in New Zealand during the period under study declined even more than among legitimate infants. In this connection, it might be mentioned that in New South Wales in Australia, where a system of infant life protection similar to that in New Zealand has been in force since 1891, with amendments in 1904 and changes in regulations at other times, the mortality rate among illegitimate infants fell from 276 deaths per 1,000 births in the period 1895-99 to 108 deaths per 1,000 births in 1919.

WORK OF THE ROYAL NEW ZEALAND SOCIETY FOR THE HEALTH OF WOMEN AND CHILDREN

Probably the most important of the preventive measures is the work of the Royal New Zealand Society for the Health of Women and Children. This society was organized in Dunedin in 1907 by Dr. Truby King, and was formed to carry on work which he had already commenced for the better care of very young children.

The work of the society has been fully described in bulletins of the U. S. Children's Bureau.⁸

The society is organized in a number of independent branches which meet in conference or council at stated intervals. The central council is mainly for the purpose of conference or discussion, but also considers the policy of the society as a whole, especially in regard to coöperation with the Health Department. It receives subsidies granted by the Health Department and distributes them to the local branches. Except for a paid secretary of the central council, and for the nurses, all the work of the society is on a volunteer basis.

An important feature of organization is decentralization. Each local branch is independent financially and in the management of its local work, though it keeps in touch with other branches through the central conference. The branches are managed by special committees consisting of 15 or 20 members. They depend for their support, except for the government subsidies for the payment of nurses as already mentioned, upon subscriptions and donations raised in the locality. In this way the active interest and coöperation of the localities is secured and maintained. Outlying branches in rural communities which can not afford to maintain nurses of their own often secure part time services of the nurses in nearby cities.

The branch at Dunedin, which was formed first,

⁸ New Zealand Society for the Health of Women and Children, *An Example of Methods of Baby-Saving Work in Small Towns and Rural Districts*, Children's Bureau Publication No. 6. Washington, 1914. *Infant Mortality and Preventive Work in New Zealand*. Children's Bureau Publication No. 105. Washington, 1922.

maintains a special hospital for the training of all the nurses employed by the various branches.⁹

A very important feature of the work of the society is the training of its nurses. Plunket nurses, as they are called in honor of Lady Plunket, wife of a former Governor of New Zealand, who took great interest in the work of the society, are all registered general or maternity nurses who have had a sort of post-graduate training at a special baby hospital maintained by the society at Dunedin. In this hospital babies are received for dietetic treatment only. Nurses are given careful and thorough instruction in the general methods of care, particularly in the preparation of so-called humanized (a special kind of modified) milk, in clothing, hours of sleep, and other details. The period of training is 3 months for nurses with general training and 6 months for nurses with special maternity training only.

A number of nurses have been sent from Australia to take the special training given to the Plunket nurses, and in New South Wales a nurses' training school has been established on the model of that conducted by the Royal New Zealand Society.

The principal lines of work followed are maintenance of infant welfare or baby health centers, at which the specially trained Plunket nurses give free advice in regard to all matters relating to the care of babies, except purely medical matters. The mothers bring their babies to the centers for advice in regard to diet; from

⁹ Two other branches, Christchurch and Wanganui, also maintain special hospitals for babies, but do not train Plunket nurses. Nurses without previous training but with a full year's training in these hospitals are designated as Karitane nurses.

the centers the nurses also make visits to the homes. The policy of the society is everywhere to encourage breast feeding, but if that is not possible, humanized milk is recommended and demonstrations as to the method of preparing it are given. The nurses never prescribe for sick infants but advise the mothers to call a physician. An important feature is the general instruction given in regard to proper clothing, fresh air, and hours of sleep. Besides the individual work with mothers and babies, the society supplies a column which is printed weekly in most of the newspapers in New Zealand. The society also distributes, at nominal cost, booklets and pamphlets in regard to the care of infants. One of these pamphlets, "The Expectant Mother and Baby's First Month" has been taken over and published by the Health Department, and is distributed free of cost to every mother on the registration of the birth of her baby.

Another feature of the work is that all apparatus and methods used are so simple that any mother can secure and apply them in her own home.

It should also be mentioned that the society does not confine its work simply to the children of the poorer classes, but on the contrary, urges mothers in all classes to use the services of the Plunket nurses. The work of the society is, indeed, well known and appreciated among the well-to-do—"the upper classes"—and the desire to imitate these classes has become an influence in spreading the use of its facilities among those who are not so well off. This fact also helps to remove any feeling that the work is merely a charity.

In regard to the growth and extent of this work,

very little statistical information is available. The society has published annual reports, but the statistics presented are somewhat fragmentary.

Branches were organized in 1907 and 1908 in the four principal cities. The number of main branches at which Plunket nurses are stationed has gradually increased until in March, 1926, it was 59; in addition there were a number of sub-branches in outlying districts. Local committees were formed in a number of other smaller places. The number of Plunket nurses gradually increased to 28 in 1916, 46 in 1920, and 98 in 1926.

In the year ended March 31, 1919, the total number of babies cared for was 15,951, a figure which increased to 41,635 in 1925-6. This figure, however, includes not only infants brought for the first time under the care of the society, but also infants cared for at any time during the year who had also been under care in a previous year. Babies are usually first brought under care before they are one year old, and very rarely after passing the first birthday; but after having formed the habit of consulting the Plunket nurses, mothers frequently bring their babies, as they are indeed urged to do, at intervals until they reach two years of age.

The number of infants brought under care for the first time may fairly be compared with the number of births to show roughly the proportion of infants born in New Zealand who are brought directly under the influence of the Plunket nurses. The figure for 1919, furnished through the courtesy of the Health Department to which the society makes monthly reports, was 6,454, which, when compared with the total num-

ber of births for that year, gives 26.4 per cent, or over one-fourth of all the New Zealand babies cared for by the society. The proportion was much higher in the cities in which most of the work is centered. But even outside the four principal cities, approximately one-sixth of all births came directly under the care of the society even at that time.

TABLE 44

Proportion of infants brought directly under care of the Plunket Society, 1919

PLACE	BIRTHS, 1919*	INFANTS BROUGHT UNDER CARE FOR FIRST TIME DURING 1919	
		Number†	Per cent of births
New Zealand.....	24,483	6,454	26.4
Four chief cities (metropolitan areas).....	7,683	3,337	43.4
Remainder of Dominion.....	16,800	3,117	18.6

* Statistics of the Dominion of New Zealand, 1919, Vol. I, Population and Vital Statistics, pp. 33 and 85.

† From manuscript table furnished by courtesy of the Department of Health of New Zealand.

Figures for the year ended March, 1926, compiled by the Royal New Zealand Society, gave 13,819 new cases, which is nearly 50 per cent of all babies born. Evidently since 1919 a substantial increase in the proportion of babies reached by the Plunket nurses has taken place.

It should be pointed out that the infants who are brought directly under the supervision of the Plunket nurses—nearly one-half the infants born—probably include the great majority of those most in need of

such care; furthermore, a large proportion of the remainder are doubtless reached by the educational measures of the society and by the distribution of pamphlets.

In conclusion, certain influences have been operating steadily toward a decrease in infant mortality throughout the period. These influences include the gradual increase in medical knowledge of the best methods of disease prevention, the raising of the level of training in the medical profession, the improvements in public sanitation, the gradual extension of the public-health work in the Dominion as shown in the increase of powers and the improvements in methods of administration in the health department, and the gradual education of the public in methods of preventing disease and of maintaining health. These movements are difficult to trace in their individual effects upon infant mortality, but their combined influence is written plainly in the gradual and steady improvement in the rates of infant mortality from epidemic diseases and tuberculosis, as well as in the decline in infant mortality from respiratory and from gastric and intestinal diseases which occurred during the period from about 1875 to 1905.

The marked acceleration in the rate of decline in infant mortality beginning about 1905 points clearly to the presence of new causes operating to produce it. Study of the work of various governmental and private agencies, so far as they affected infant welfare during the period under review, suggests three principal movements as responsible in the main for this acceleration.

The establishment of State maternity hospitals for the training of maternity nurses was a very important beginning in a gradual raising of the level of maternity care available. The compulsory registration of midwives and the voluntary registration of nurses were further steps toward securing better maternity and general nursing service.

The work of the St. Helens Hospitals, although especially directed toward providing for better confinement care for the wives of working men, offers large possibilities for the reduction of the infant mortality rate from causes peculiar to early infancy—causes which are related to the care and condition of the mother. The decrease of one-half in the infant mortality rate during the first month of life secured in New York City by systematic prenatal supervision shows in a striking way what can be accomplished in the further reduction of the rate from causes peculiar to early infancy.¹⁰ As yet the St. Helens Hospitals provide nursing and confinement services for the mothers of only about one-tenth of the infants born in New Zealand, and have paid comparatively little attention to the need for prenatal care. Nevertheless, their work already appears to have had a slight influence on the mortality from causes peculiar to early infancy.

The work of infant-life protection is another important factor in the reduction of infant mortality. This work reaches only babies boarded out apart from their

¹⁰ Baker, S. Josephine, M.D., and Sobel, Jacob, M.D.: "Control of Infant Morbidity and Mortality in New York City," in *Monthly Bulletin of the Department of Health, City of New York*, Vol. XI (October, 1921), p. 233.

mothers; this group, for the most part of illegitimate birth, is one in which infant mortality is generally high, and is therefore in especial need of supervision. Since the improvement of the inspection service due to the employment of trained inspectors for infants' homes, the reduction in mortality among these infants has been marked.

The most important influence in the reduction of the infant mortality rate is undoubtedly the work of the Royal New Zealand Society for the Health of Women and Children. Organized in 1907 in Dunedin, its work spread to other cities and has gradually enlarged until in 1925 it reached directly through its infant-welfare centers nearly half of all the babies born in New Zealand. Through its newspaper health articles and through its distribution of pamphlets, including the distribution of its principal pamphlet through the Department of Health upon the registration of births, the society also undoubtedly exerts an important influence over a large proportion of those infants not directly reached by the Plunket nurses. The emphasis laid upon breast feeding and, in case breast feeding is not possible, upon "humanized milk" makes for a reduction in the mortality from gastric and intestinal diseases, while general instruction in infant hygiene, the value of fresh air, proper clothing, and other matters, doubtless exerts an important influence in reducing the mortality from respiratory diseases.

These new movements, together with the conditions favorable to low infant mortality rates already described, are doubtless responsible for New Zealand's position as the country with the lowest infant mortality rate in the world.

APPENDIX

THE TREND OF MATERNAL MORTALITY RATES IN THE UNITED STATES DEATH REGISTRATION AREA, 1900-1921¹

In Chapter III the close connection between the health of the mother and the infant mortality rate was pointed out and particular attention was called to the heavy mortality among infants whose mothers died within one year after their births. The trend of the maternal mortality rate is, therefore, of great interest in connection with the trend of the infant mortality rate.

The maternal mortality rate in the United States death-registration area is increasing, if the statistics can be accepted. Apart from the question of the reliability of the figures, such a conclusion is surprising in view of the increased attention paid to medical education and to public-health administration and the increasing interest that the public takes in questions of health. Before the conclusion is accepted, therefore, the evidence for the increase in the rate of maternal mortality should be examined critically.

In table 45 the death rates from all puerperal causes per 100,000 population are given for the expanding death-registration area. The rate from all causes apparently increased from 13.3 in 1900 to 16.9 in 1921. From puerperal septice-mia it increased from 5.7 in 1900 to a maximum of 7.4 in 1911, from which point it decreased to 6.8 in 1921. From other puerperal causes it increased from 7.6 in 1900 to 10.1 in 1921.

¹ Reprinted by permission from the American Journal of Public Health, Vol. XIV, pp. 738-743, September, 1924. A summary of a chapter in a report on Maternal Mortality, United States Children's Bureau Publication No. 158.

In this comparison rates expressed in terms of population are used because satisfactory birth statistics are not available throughout the period for the whole area. But the real risk of death from puerperal causes can best be measured

TABLE 45

Trend of mortality rates from puerperal causes: expanding death-registration area, 1900-1921

YEAR	DEATHS FROM PUERPERAL CAUSES, PER 100,000 POPULATION		
	Total	Puerperal septicemia	Other puerperal causes
1900	13.3	5.7	7.6
1901	13.7	6.0	7.7
1902	13.0	5.7	7.3
1903	14.0	6.1	7.9
1904	15.3	6.9	8.5
1905	14.9	6.8	8.1
1906	15.1	6.2	8.9
1907	15.6	6.8	8.9
1908	15.7	7.0	8.7
1909	15.3	6.7	8.6
1910	15.7	7.2	8.5
1911	16.0	7.4	8.6
1912	15.0	6.5	8.5
1913	15.8	7.2	8.7
1914	16.0	7.1	8.9
1915	15.3	6.3	9.0
1916	16.3	6.7	9.6
1917	16.7	6.9	9.8
1918	22.3	6.5	15.9
1919	17.0	5.8	11.2
1920	19.0	6.6	12.5
1921	16.9	6.8	10.1

by reference to the number of cases exposed to the risk, namely, the number of births. Since the birth rate is falling, a constant puerperal mortality as measured in terms of births would show a slight decrease if measured in terms of

population; and hence these rates expressed in terms of population understate the increase in risk rates from puerperal mortality during this period. Furthermore, the slight apparent decline in the mortality from puerperal septicemia since 1911 might be the result of a stationary or even slightly increasing mortality from puerperal septicemia masked by the falling birth rate.

With the possible exception of mortality from puerperal septicemia since 1911, the figures indicate a marked increase in maternal death rates during the twenty-year period covered by the statistics. Before definite conclusions are drawn as to the extent of this increase or as to the real trend in puerperal mortality, the influence of three factors must be considered: (1) the expansion of the registration area, (2) the decrease in the birth rate, and (3) improvements in certification of cause of death.

Since these figures relate to the expanding death-registration area, the first questions which must be answered are, How much, if any, of the apparent increase is due merely to the addition to this area of states with higher puerperal mortality rates than those in the original area, and how much is due to an increase in mortality rates in the original or in the added areas? In 1900 the death-registration area included 40.5 per cent of the population of the United States; in 1920 it included more than twice as large a proportion, 82.2 per cent. A study of the mortality rates in the original registration states (including the District of Columbia but excluding registration cities in nonregistration states) and in states added during each year shows that the result of additions of new states to the area was to increase slightly the mortality rates from all puerperal causes in 1906, 1911, 1913, 1916, 1917, and 1919, and to decrease them slightly in 1908, 1909, 1910, 1914, 1918, and 1920, relatively to what they would have been if no additions had been made.

The influence of changes in territory may be eliminated in

either of two ways: The first and simpler way is to study the trend of mortality in the original registration states of 1900. In this area the rate from all causes rose from 13.4 in 1900 to 17.5 in 1920. From puerperal septicemia it rose from 5.8 in 1900 to a maximum of 7.1 in 1911, and fell to 6.1 in 1920. From all other puerperal causes, however, it showed a continuous increase from 7.6 to 11.5 during the twenty-year period under review. These increases in each case are slightly less than the increases shown in the expanding area.

This method does not take into account, however, changes in rates in the states which were added to the original registration area. In most of the added states, but not in all, the rate from all puerperal causes was higher in 1921 than in the year of admission.

A method of taking into account changes in mortality rates within the added as well as within the original territory—giving to each change its due weight in the calculation—is as follows: The percentage of change in rate from each year to the next in the territory common to both years is first ascertained. The initial rate in 1900 is multiplied by the percentage of change from 1900 to 1901 in the territory common to both years; the result is then multiplied by the percentage of change from 1901 to 1902 in the territory common to these years; and similarly each successive result is multiplied by the corresponding percentage of change. The final result is a series of adjusted figures which measure the change in maternal mortality in the expanding area after the influence of differences in initial rates in the added states is eliminated.

The series of figures so constructed is compared in table 46 with the rates in the expanding area and with those in the original registration states. A comparison of these three groups of figures shows that eliminating the influence of the expansion of the area gives a trend not far different

from the trend of the rates from puerperal causes in the original registration states.

TABLE 46

Trend of maternal mortality rates, United States death-registration area, 1900-1921

YEAR	MATERNAL MORTALITY RATES PER 100,000 POPULATION		RATIO TO 1900 RATE†		INDEX NUMBER OF RATES IN EXPANDING AREA§
	Expanding death- registration area*	Original death- registration States†	Expanding death- registration area	Original death- registration States	
1900	13.4	13.4	100.0	100.0	100.0
1901	13.2	13.2	98.8	98.8	98.8
1902	12.6	12.6	94.0	94.0	94.0
1903	13.1	13.1	97.5	97.5	97.5
1904	14.9	14.9	110.8	110.8	110.8
1905	14.6	14.6	108.8	108.8	108.8
1906	15.0	14.4	111.9	107.1	106.9
1907	15.5	15.1	115.4	112.3	110.4
1908	15.5	14.3	115.9	106.9	111.5
1909	15.0	14.4	112.2	107.6	108.6
1910	15.4	15.1	114.5	112.5	111.8
1911	15.5	15.5	115.8	115.6	111.6
1912	14.4	14.1	107.7	105.4	103.8
1913	15.5	14.9	115.3	111.5	110.2
1914	15.4	15.4	115.2	114.5	110.6
1915	14.8	14.8	110.5	110.0	106.2
1916	16.0	14.8	119.6	110.0	109.9
1917	16.5	15.5	123.0	115.2	112.6
1918	22.1	20.5	165.0	153.1	152.7
1919	16.8	15.3	125.5	113.8	114.5
1920	19.0	17.5	141.5	130.8	129.3
1921	16.7	15.1	124.5	112.6	113.8

* Exclusive of cities in non-registration States.

† Includes the six New England States, New York, New Jersey, District of Columbia, Indiana, and Michigan.

‡ The 1900 figures = 100.0.

§ For method of calculation see preceding text.

As for the second factor which must be considered before definite conclusions can be drawn, since the birth rate decreased during the twenty years from 1900 to 1920, the maternal mortality rate, when expressed in terms of deaths per 1,000 births, would show a greater increase than when expressed in terms of deaths per 100,000 population. To estimate the influence of the fall in birth rate upon the apparent changes in rates of puerperal mortality, it is necessary first to ascertain the amount of this fall; with this information its influence upon the puerperal mortality rate as stated in terms of population can easily be calculated.²

The chief difficulty in making a correction for the fall in birth rates is to ascertain the rates themselves. The registration of births in many of the states composing the death-registration area of 1900 is incomplete, and statistics based upon registered births during the period from 1900 to 1920 are subject, therefore, to errors of varying size due to omissions. Perhaps the most satisfactory method is to estimate the average number of births for the five years preceding each census date (1900, 1910, and 1920) from the enumerated populations under five years and the statistics of deaths of children under five.³ This method gives esti-

² If B_1 , B_2 are birth rates in different years, and $b = \frac{B_2}{B_1}$ (i.e., the proportion that the second birth rate is of the first, and p_1 , p_2 are the rates of puerperal mortality per 100,000 population in the same years, then if p_2 is divided by the b the result will be comparable with p_1 so far as any change in birth rate is concerned.

³ The number of births during the five-year period prior to the date of the census can be approximated by adding to the enumerated population under five years the number of children born during that period who died prior to the date of the census. The latter number is approximately equal to the sum of: (1) infants who had died under one year of age in the four years prior to the date of the census and 71 per cent of those who had died under one year of age in the fifth year before the date of the census; (2) children who had died at one year of age during the three years prior, and 59 per cent of those

mated birth rates for the original death-registration states of 25.6 in 1900, 24.0 in 1910, and 23.2 in 1920; the birth rate, therefore, appears to have decreased 9.5 per cent during these twenty years. Assuming that these estimates give a fairly accurate picture of the fluctuations in the actual birth rates during this period, table 47 indicates the trend, after allowance is made for the falling birth rate, of maternal mortality in the original death-registration states from all causes, from puerperal septicemia, and from other causes.

As would be expected, the result of this correction is to make still larger the apparent increase in mortality from puerperal causes. The rapid fall shown in the crude death rates from 1900 to 1902 appears to be caused in large part

who had died at one year of age in the fourth year prior to the date of the census; (3) children who had died at two years of age during the two years prior, and 53 per cent of those who had died at this age in the third year prior to the date of the census; (4) children who had died at three years of age during the year immediately prior, and 52 per cent of those who had died at this age in the second year prior to the date of the census; (5) 52 per cent of the children who had died at four years of age in the year immediately prior to the census date. (For method see United States Life Tables, 1890, 1901, 1910, 1901-1910, p. 340.) By this method estimates of births were made for the periods 1895-99, 1905-09, 1915-19; the deaths under five years in the years 1895-99 were estimated from those in the period from 1900-04 by reducing them in the same proportion that the estimated number of births in 1895-99 was less than the estimated number of births in 1900-04. From these figures birth rates for each year from 1900 to 1920 were calculated on the assumption of a uniform rate of fall; these were then modified to take account of fluctuations in the birth rate from year to year by multiplying by a factor found by dividing the actual number of registered births in each year by one-fifth the sum of the actual number of registered births in the five-year period in which the particular year was the middle one. In this calculation no allowance was made for omissions from the census population under five years nor for variations in the proportion of such omissions.

by the markedly lower birth rates in the years 1901 and 1902 as compared with that in 1900, which was unusually high. The decrease in mortality from puerperal septicemia

TABLE 47

Trend in maternal mortality rates after allowance is made for falling birth rate, 1900-1921; United States death-registration States of 1900

YEAR	TREND IN BIRTH RATE: (1900 RATE = 100.0)	TREND IN DEATH RATES: (1900 RATE = 100.0)					
		All puerperal causes		Puerperal septicemia		Other puerperal causes	
		Crude figures	Adjusted for falling birth rate	Crude figures	Adjusted for falling birth rate	Crude figures	Adjusted for falling birth rate
1900	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1901	96.5	98.8	102.4	95.3	98.8	101.4	105.0
1902	96.1	94.0	97.9	91.8	94.5	96.5	100.4
1903	97.4	97.5	100.2	94.0	96.5	100.2	102.9
1904	95.8	110.8	115.6	112.2	117.1	109.6	114.5
1905	93.6	108.8	116.2	109.9	117.4	107.9	115.3
1906	95.8	107.1	111.8	100.3	104.7	112.3	117.1
1907	97.0	112.3	115.8	111.6	119.6	112.8	116.3
1908	97.4	106.9	109.7	106.3	109.1	107.4	110.2
1909	92.6	107.6	116.2	106.1	114.6	108.7	117.4
1910	93.8	112.5	120.0	116.5	124.3	109.5	116.7
1911	94.3	115.6	122.6	123.3	130.8	109.8	116.4
1912	93.4	105.4	112.9	103.3	110.6	107.1	114.6
1913	92.4	111.5	120.6	113.5	122.8	109.9	119.0
1914	93.8	114.5	122.0	113.3	120.8	115.3	122.9
1915	92.8	110.0	118.5	102.4	110.3	115.7	124.7
1916	92.3	110.0	119.2	105.6	114.4	113.3	122.8
1917	95.0	115.2	121.2	110.4	116.2	118.9	125.1
1918	94.0	153.1	162.8	97.2	103.3	195.4	207.8
1919	86.5	113.8	131.6	89.7	103.7	132.1	152.7
1920	90.5	130.8	144.4	104.7	115.7	150.5	166.2
1921	91.2	112.6	123.4	105.1	115.2	118.3	129.6

from 1911 to 1921, which in the crude figures appeared to be 14.8 per cent, was reduced, after allowance was made for the falling birth rate, to 11.9 per cent. The conclusion

might be drawn that though, since 1911 at least, the mortality from puerperal septicemia in the original death-registration states has actually decreased, the trend of the rates from "other puerperal causes" appears even more definitely upward than would be inferred from the crude figures.

The improvement in the certification of causes of death during the period from 1900 to 1920 is the third factor which must be taken into account in determining whether the mortality from puerperal causes is actually increasing. The result of the campaign for obtaining more accurate reporting of causes of death and for querying unsatisfactory causes reported has been to make the statistics for the later years of the period more nearly correct than those for the earlier years.

So far as mortality from puerperal septicemia is concerned, the first inquiries put out directly by the Bureau of the Census to the physicians concerned related to deaths in 1911, and in that year the death rate from puerperal septicemia reached its maximum. Since in the changes made as a result of the inquiries the number of cases added to puerperal septicemia has always exceeded the number of cases subtracted from it, the decrease in the rate since that year points to an improvement in mortality from this cause. The real improvement is greater than appears on the face of the figures, because it is in part masked by the continual betterment of certification resulting from extension of the system of querying unsatisfactory certifications of cause.

The influence of the improvement in accuracy of certification, so far as the net additions made to puerperal deaths as a direct result of letters of inquiry to physicians are concerned, may be eliminated by subtracting the additions. The numbers of cases added are given in Mortality Statistics for the entire death-registration area for each year since 1911, with the exception of 1912, 1913, and 1918.

But these numbers added were in no case over 3.5 per cent, a percentage which represents, therefore, the maximum correction for such additions.

This method of correction, however, obviously cannot eliminate additions resulting indirectly from the system of letters of inquiry because of the fact that physicians who have received such letters are likely to be more careful afterwards in reporting causes of death.

The influence of the increasing accuracy in certification which is reflected in a decrease in the proportion of deaths classified as due to ill-defined and unknown causes may be estimated and eliminated, so far as transfers from these indefinite to puerperal causes are concerned. In 1900 the proportion of deaths from ill-defined and unknown causes in the death-registration states was 3.8 per cent, whereas in 1920 in the same area it was only 0.2 per cent. In 1921 only 942 deaths in this area were classified as due to ill-defined and unknown causes, as compared with 13,199 that would have been so classified if the proportion that prevailed in 1900 had prevailed also in 1921. Of the deaths from these indefinite causes in 1900, 2.8 per cent were of women between the ages of ten and fifty years. Assuming that the same proportion of these were connected with pregnancy or childbirth as the puerperal deaths formed of the total at these ages from known causes (11.7 per cent), then it may be estimated that 0.33 per cent of the total deaths from ill-defined causes were maternal. On this assumption the number probably added to puerperal deaths by transfer from ill-defined causes has been estimated; but this correction reduces the index number for the later years, showing the trend of mortality from 1900, only from 1 to 2 per cent.

Neither of the preceding methods, however, takes account of improvements due to the campaign for better certification of causes of death, so far as they have reduced the

mortality ascribed either to such poorly defined terms as septicemia and convulsions or to terminal conditions such as peritonitis and nephritis, the true or underlying cause of which may be puerperal. An estimate of the effect of such improvements in certification can be made on the following assumptions: First, that the excess in the actual number of female deaths at ages fifteen to forty-nine over the number expected—if the ratio of female to male deaths at these ages was the same as the average ratio of female to male deaths under fifteen and over fifty years of age—represents transfers from causes of death peculiar to women; and secondly, that 80 per cent of these were transfers from puerperal causes.⁴ On the basis of these assumptions the total number of maternal deaths, including those ascribed to poorly defined terms and terminal conditions, in each year from 1900 to 1921 has been calculated; and in table 48 the rates based upon a comparison of these deaths with the estimated births are given to indicate the trend in maternal mortality after allowance is made for improvements in certification in these cases.

The trend in the maternal mortality rates, after allowance has been made for transfers from these five poorly defined terms and terminal conditions and from ill-defined and unknown causes, is strikingly different from that shown in preceding tables. From all causes the trend appears to have been very slightly downward, the highest rate, with the exception of that for 1918 when influenza was a factor, being for 1900. The trend of mortality from puerperal septicemia, however, appears to have been sharply downwards throughout the period, the figures indicating a decrease of 36 per cent during these twenty years. From

⁴ Of all deaths from ten to forty-nine years of age from causes peculiar to women 77.5 per cent were puerperal in 1900 and 80.1 per cent in 1920; 80 per cent is taken as a rough approximation to an average percentage.

other puerperal causes the rates appear fairly uniform except in 1918, 1919, and 1920, when they were abnormally high.

TABLE 48

*Estimated trend in maternal mortality rates by cause of death, after allowance is made for improvement in certification of causes of death; United States death-registration states as of 1900, 1900-1920**

YEAR	ESTIMATED DEATH RATES PER 1,000 LIVE BIRTHS					
	Puerperal causes		Puerperal septicemia		All other	
	Rate	Trend (1900 rate = 100.0)	Rate	Trend (1900 rate = 100.0)	Rate	Trend (1900 rate = 100.0)
1900	8.5	100.0	4.3	100.0	4.2	100.0
1901	8.0	94.3	3.7	86.8	4.3	101.9
1902	7.4	86.8	3.6	83.2	3.8	90.4
1903	7.0	82.1	3.3	78.2	3.6	86.1
1904	7.9	92.6	3.9	91.0	4.0	94.2
1905	8.0	94.2	3.8	88.1	4.2	100.5
1906	7.1	83.5	3.2	73.8	3.9	93.2
1907	7.2	85.0	3.3	77.8	3.9	92.3
1908	6.7	79.2	3.0	71.1	3.7	87.4
1909	7.0	82.6	2.9	69.0	4.1	96.4
1910	6.9	81.0	3.1	72.8	3.8	89.4
1911	7.0	82.5	3.2	75.4	3.8	89.6
1912	6.5	76.6	2.7	63.0	3.8	90.3
1913	6.8	80.0	2.9	67.6	3.9	92.4
1914	7.1	83.2	2.9	68.0	4.2	98.5
1915	6.9	81.2	2.6	60.9	4.3	101.8
1916	6.7	78.8	2.7	63.0	4.0	94.8
1917	6.6	78.3	2.8	64.8	3.9	91.9
1918	9.3	109.2	2.5	58.2	6.8	160.8
1919	7.5	88.2	2.4	57.4	5.0	119.5
1920	7.8	91.8	2.7	64.0	5.1	120.0

* For method of calculation see text. The allowance made is for estimated additions to puerperal deaths from ill-defined and unknown causes and from peritonitis, septicemia, convulsions (unqualified), acute nephritis and Bright's disease.

The validity of these conclusions rests obviously upon the validity of the method of estimate of the number of puerperal deaths that were roughly classified in past years as due to poorly defined and terminal, rather than to causal, conditions. In support of the method it should be mentioned that marked decreases in mortality from "septicemia," "peritonitis," and "convulsions (unqualified)" have occurred during the twenty-year period, and that, in part at least, deaths from these causes have been transferred to puerperal septicemia and other puerperal causes. Furthermore, a decrease in maternal mortality would be expected in view of the experience of other countries and especially in view of the marked improvement in standards of medical education and medical licensure in this country.

The figures, therefore, raise a strong presumption that the mortality from puerperal septicemia actually decreased throughout the period from 1900 to 1920, while that from other puerperal causes remained approximately the same.

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